CURRICULUM & SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

BACHELOR OF SCIENCE (B.Sc. - HONORS)

(3 Year Undergraduate Degree Programme)

IN

MATHEMATICS

[w. e. f. 2020-21]

FACULTY OF SCIENCE & HUMANITIES

SRM UNIVERSITY DELHI-NCR, SONEPAT

Plot No.39, Rajiv Gandhi Education City, P.S. Rai, Sonepat

Haryana-131029

SRM UNIVERSITY DELHI-NCR, SONEPAT (HARYANA)

VISION

SRM University Haryana aims to emerge as a leading World Class Institution that creates and disseminates knowledge upholding the highest standards of instruction in Engineering & Technology, Science & Humanities, Commerce, Management, Hotel Management & Medicine & Health Science. Along with academic excellence, our curriculum imparts integrity and social sensitivity so that our graduates may best serve the Nation and the World.

MISSION

- To create a diverse community campus that inspires freedom and innovation.
- Strengthen Excellence in educational & skill development processes
- Continue to build productive international alliances
- Explore optimal development opportunities available to students and faculty
- Cultivate an exciting and rigorous research environment

DEPARTMENT OF MATHEMATICS

VISION

The Department of Mathematics strives:

- To foster experimental, problem-oriented and discovery learning of mathematics.
- Designing a mathematics phobia through authentic learning based on hands-on experience with computers
- To provide greater scope for individual participation in the process of learning and becoming autonomous learners.
- To provide scope for greater involvement of both the mind and the hand which facilitates cognition?
- To ultimately see that the learning of mathematics becomes more alive, vibrant, relevant and meaningful; a program that paves the way to seek and understand the world around them. A possible by-product of such an exercise is that math-phobia can be gradually reduced amongst students.
- To help the student build interest and confidence in learning the subject.

MISSION

The Department of mathematics offers the course:

- To get students started to enjoy mathematics, solve abstract problems and use abstraction to understand relationships and structure, and to understand the basic structure of mathematics
- To Increase retention of mathematical concepts in the student.
- To develop a spirit of inquiry in the student.
- To improve the perspective of students on mathematics as per modern requirement.
- To enable the teacher to display, explain and reinforce abstract mathematical ideas using solid objects, models, charts, graphs, diagrams, posters with the help of FOSS tools on the computer.
- To make the learning process student-friendly by having a change in focus in mathematical teaching, especially in the mathematical learning environment.
- To exploit techno-savvy nature in the student to overcome math-phobia.
- To set up a math lab to help students discover mathematical concepts through activities and experimentation.

PROGRAM REQUIREMENT

General Education Requirements: Applied Science and Humanities (ASH)

Basic Science Requirements: Fundamental Sciences (FS) through regular/online mode

Disciplinary Requirements comprising of:

Department of Mathematics Core courses (through regular/online mode)

Department of Mathematics Electives (through regular/online mode)

Practical and Research component:

1. Regular Practical and Research
2. Minor and Major Project

SEMESTER-I

Code	Category	Course	L	T	P	C
20BMH0101	CORE	Groups and Rings	4	1	0	5
19BMH0102	CORE	Calculus	4	1	0	5
	GE	Generic Elective – I	3	0	2	4
	SEC	Skill Enhancement Course– I	2	0	2	3
20AEC0101	Ability Enhancement Compulsory Course - I	Communicative English	4	0	0	4
Total			17	2	4	21
Total Contact Hours			23			

SEMESTER-II

Code	Category	Course	L	T	P	C
20BMH0201	CORE	Linear Algebra and Matrices	4	1	0	5
19BMH0202	CORE	Ordinary Differential Equations	4	1	0	5
	GE	Generic Elective – II	3	0	2	4
	SEC	Skill Enhancement Course – II	3	0	0	3
20AEC0102	Ability Enhancement Compulsory Course – II	Environmental Studies	3	0	0	3
Total			17	2	2	20
Total Contact Hours			21			

SEMESTER-III

Code	Category	Course	L	T	P	C
19BMH0301	CORE	Mechanics	4	1	0	5
20BMH0302	CORE	Theory of equations	4	1	0	5
19BMH0303	CORE	Operations Research I	4	1	0	5
19BMH0304	CORE	Multivariate Calculus	4	1	0	5
	DSE	Discipline Specific Elective-I	4	1	0	5
Total			20	5	0	25
Total Contact Hours			25			

SEMESTER-IV

Code	Category	Course	L	T	P	C
19BMH0401	CORE	Complex Analysis	4	1	0	5
19BMH0402	CORE	Partial Differential Equations	4	1	0	5
20BMH0403	CORE	Analysis I	4	1	0	5
20BMH0404	CORE	Probability and Statistical Methods	4	1	0	5
	DSE	Discipline Specific Elective-II	4	1	0	5
Total			20	5	0	25
Total Contact Hours			25			

SEMESTER-V

Code	Category	Course	L	T	P	C
19BMH0501	CORE	Numerical Methods	4	1	0	5
20BMH0502	CORE	Analysis II	4	1	0	5
19BMH0503	CORE	Number Theory	4	1	0	5
	DSE	Discipline Specific Elective-III	4	1	0	5
19BMH0507	P	Minor Project	4	0	0	4
Total			20	4	0	24
Total Contact Hours			24			

SEMESTER-VI

Code	Category	Course	L	T	P	C
19BMH0601	CORE	Metric Spaces	4	1	0	5
19BMH0602	CORE	Vector Analysis	4	1	0	5
19BMH0603	CORE	Descriptive Statistics and Distribution Theory	4	1	0	5
	DSE	Discipline Specific Elective-IV	4	1	0	5
19BMH0607	P	Major Project	6	0	0	6
Total			22	4	0	26
Total Contact Hours			26			

SUMMARY OF CREDITS

Category	I Sem	II Sem	III Sem	IV Sem	V Sem	VI Sem	Total	%
CORE	10	10	20	20	19	21	100	70.92
GE	4	4	-	-	-	-	8	5.67
SEC	3	3	-	-	-	-	6	4.25
AECC	4	3	-	-	-	-	7	4.96
DSE	-	-	5	5	5	5	20	14.18
Total	21	20	25	25	24	26	141	

EVALUATION SCHEME

INTERNAL EVALUATION (THEORY)

Assessment	Internal Assessment-I	Internal Assessment-II	Internal Assessment-III	Internal Assessment-IV	Internal Assessment-V	Total
Marks	10	10	10	10	10	50

INTERNAL EVALUATION (PRACTICAL)

Assessment	Daily Assessment/Observation	Programs performed during Lab hours	Programs performed during Internal practical Examinations	Viva- Voce	Total
Marks	10	10	15	15	50

EXTERNAL EVALUATION (THEORY)

Assessment	End Semester Examination	Total
Marks	100	Will be scaled in 50

EXTERNAL EVALUATION (PRACTICAL)

Assessment	Record File	Programs performed during External Practical Examinations	Written Work	Viva- Voce	Total
Marks	10	10	15	15	50

Note:

1. The evaluation Scheme may change as per the university guidelines.
2. Evaluation scheme of Industrial training may vary department wise.
3. Evaluation scheme project/minor project may vary department wise.
4. Department are advised to add the evaluation scheme in their respective curriculum.

PROGRAM OBJECTIVE

Students, who choose BMH Programme, develop the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life. Pursuing a degree in mathematics will introduce the students to a number of interesting and useful ideas in preparations for a number of mathematics careers in education, research, government sector, business sector and industry.

- The programme covers the full range of mathematics, from classical Calculus to modern Cryptography, Information Theory, and Statistical computation.
- The course lays a structured foundation of Calculus, Real & Complex analysis, Abstract Algebra, Differential equations (including Mathematical modeling), Number theory, Graph theory, and C++ programming exclusively for mathematics.
- An exceptionally broad range of topics covering Pure & Applied Mathematics: Linear Algebra, Metric spaces, Statistics, Linear Programming, Numerical Analysis, Mathematical Finance, Coding theory, Mechanics and Bio-Mathematics cater to varied interests and ambitions.
- To broaden the interest for interconnectedness between formerly separate disciplines one can choose from the list of Generic electives for example one can opt for economics as one of the GE papers.
- Skill enhancement Courses enable the student acquire the skill relevant to the main subject.
- Choices from Discipline Specific Electives provides the student with liberty of exploring his interests within the main subject. Of key importance is the theme of integrating mathematical and professional skills.
- The well-structured programme empowers the student with the skills and knowledge leading to enhanced career opportunities in industry, commerce, education, finance and research.

PROGRAM OUTCOME

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The completion of the BMH Programme will enable a student to:

- Communicate mathematics effectively by written, computational and graphic means.
- Create mathematical ideas from basic axioms.
- Gauge the hypothesis, theories, techniques and proofs provisionally.
- Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.
- Identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a plethora of fields and research.

LIST OF OPEN ELECTIVES

Code	Category	Course	L	T	P	C
Generic Elective-I						
20GEPH101	GE	Physics – I: Waves & Optics	3	0	0	3
19GEPH 103	GE	Physics Laboratory-I	0	0	2	1
CYG-101	GE	Physical Chemistry	3	0	0	3
CYG-101L	GE	Physical Chemistry Practical	0	0	2	1
19BMH0103	GE	Operating Systems	3	0	0	3
19BMH0103L	GE	Operating Systems Lab	0	0	2	1
Generic Elective-II						
19GEPH102	GE	Physics – II: Elements of Modern Physics	3	0	0	3
19GEPH 104	GE	Physics Laboratory-II	0	0	2	1
CYG-102	GE	Inorganic Chemistry& Organic Chemistry	3	0	0	3
CYG-102L	GE	Inorganic & Organic Chemistry Practical	0	0	2	1
20BMH0203	GE	Programming in MATLAB	3	0	0	3
19BMH0203L	GE	Programming using MATLAB	0	0	2	1
Skill Enhancement Course– I						
20BMH0104	SEC	Programming in C++	2	0	0	2
20BMH0104L	SEC	C++ Programming Lab	0	0	2	1
19BMH0105	SEC	Programming in R	2	0	0	2
19BMH0105L	SEC	R Programming Lab	0	0	2	1
Skill Enhancement Course– II						
19BMH0204	SEC	Data Structures	3	0	0	3
20BMH0205	SEC	Logic & Sets	3	0	0	3

LIST OF MODULE ELECTIVES

Code	Category	Course	L	T	P	C
Discipline Specific Elective-I						
19BMH0305	DSE	Applications of Algebra	4	1	0	5
19BMH0306	DSE	Integral Transforms	4	1	0	5
19BMH0307	DSE	Econometrics	4	1	0	5
Discipline Specific Elective-II						
19BMH0405	DSE	Operations Research II	4	1	0	5
19BMH0406	DSE	Mathematical Modeling	4	1	0	5
19BMH0407	DSE	Industrial Mathematics	4	1	0	5
Discipline Specific Elective-III						
20BMH0504	DSE	Non Liner Programming and Simulation Theory	4	1	0	5
19BMH0505	DSE	Topology	4	1	0	5
19BMH0506	DSE	Bio-Mathematics	4	1	0	5
Discipline Specific Elective-IV						
19BMH0604	DSE	Discrete Mathematics	4	1	0	5
20BMH0605	DSE	Fuzzy Set Theory	4	1	0	5
19BMH0606	DSE	Differential Geometry	4	1	0	5

SEMESTER I

Course Code	Subject Name	L	T	P	C
20BMH0101	Groups and Rings	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. The course provides the understanding of basic algebraic structures and demonstrates an understanding of the relationship of abstract algebra.
2. The course aims to provide an introduction to some of the most fundamental algebraic structures encountered in algebra such as groups, rings, and fields.

UNIT	Course contents	Contact Hours
Unit-I	Definition of a group with example and simple properties of groups, Subgroups and Subgroup criteria, Generation of groups, Cosets, Left and right cosets, Index of a sub-group.	10
Unit-II	Coset decomposition, Largrage's theorem and its consequences, Normal subgroups, Quotient Groups,cyclicgroups.Permutations groups, Even and odd permutations, AlternatingGroups.	10
Unit-III	Homomorphisms, isomophisms, automorphisms and inner automorphisms of a group. Automorphisms of cyclic groups, Cayley's theorem, Center of a group and derived group of a group.	10
Unit-IV	Introduction to rings, subrings, Characteristics of a ring, Ring homomorphisms, ideals (principle, prime and Maximal) and Quotient rings.	10
Unit-V	Integral domains and fields, Field of quotients of an integral domain, Euclidean rings.	10

LEARNING OUTCOME: Upon completing this course, students will able to:

1. Know the concepts of groups, rings and fields.
2. Understand the notions of homomorphism and isomorphism in groups, rings, and fields.
3. Understand the notion of normal subgroup and ideal.
4. Understand the construction of a quotient groups and rings**.**
5. Understand polynomial rings and unique factorization domain.

Learning Resources	
Text Book	1. Surjeet Singh and QaziZameeruddin, Modern Algebra, Revised Edition, 2006. 2. VivekSahai and VikasBist, Algebra, Narosa Publishing House, 4th Edition, 2018.
Reference Book and other materials	1. I.S. Luthar and I.B.S. Passi, Algebra, Naorsa Publishing House,Vol.-II, 2013. 2. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 2nd Edition, 1975. 3. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 2nd Edition, 1994.

Course Code	Subject Name	L	T	P	C
19BMH0102	Calculus	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course provides fundamental knowledge of calculus.
2. Further, this course focuses on differential and integral calculus along with their applications.

UNIT	Course contents	Contact Hours
Unit-I	Limit continuity and Differentiability: limit of single variable function, indeterminate forms, continuity and discontinuity of single variable function, differentiability of single variable function, Rolle's Theorem, mean value theorems	10
Unit-II	Successive Differentiation: Successive differentiation, Leibnitz's theorem and their application, Taylor's theorem with Lagrange's and Cauchy's forms of Taylor's series, Maclaurin's series.	10
Unit-III	Application of Differentiation: curvature, asymptotes, singular points, curve tracing of Cartesian curve, curve tracing of polar curve	10
Unit-IV	Integration: definite integral as limit of a sum, integration of hyperbolic and inverse hyperbolic functions, reduction formulae	8
Unit-V	Length and area under curve: Arc length of Cartesian curve, arc length of parametric curve, arc length of polar curve, area bounded by Cartesian curve, area bounded by parametric curve, area bounded by polar curve. Volume of solid of revolution by Integration: Volume of solid of revolution for Cartesian curve, volume of solid of revolution for parametric curve, volume of solid of revolution for polar curve	12

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Understand concepts of limit, continuity and differentiability, Rolle's Theorem and Mean value theorems.
2. Understand the consequences of the intermediate value theorem for continuous functions.
3. Do successive differentiation and know of Leibnitz's theorem.
4. Interpret a function from an algebraic, numerical, graphical and verbal perspective and extract relevant information.

Learning Resources	
Text Book	1. Shanti Narayan and P.K. Mittal, Differential Calculus, S. Chand &Company, Revised Edition, 2018. 2. Shanti Narayan and P.K. Mittal, Integral Calculus,S. Chand &Company,Revised Edition, 2014.
Reference Book and other materials	1. George, B., Thomas, Jr., Ross L. Finney, Late Jan. D. Weir Giordano, Thomas Calculus, Pearson, 10th Edition, 2005. 2. Frank Ayres and Elliott Mendelson, Calculus,McGraw-Hill, 6th Edition, 2013. **3.** Robert T Smith and Roland Minton, Calculus: Early Transcendental Functions, 4th Edition, 2012.

SEMESTER II

Course Code	Subject Name	L	T	P	C
20BMH0201	Linear Algebra and Matrices	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course provides the knowledge of vector spaces and linear transformations.
2. This also demonstrates an understanding of the relationship of linear algebra and Matrices.

UNIT	Course contents	Contact Hours
Unit-I	**Vector Spaces-I:** Vectors in two dimensional space and n-dimensional space, Vectors addition and scalar multiplication of Vectors ,Vector Spaces Definition and Examples General properties of vector spaces, internal and external composition, Vector subspaces, Algebra of subspaces, Union and Intersection, Linear sum of subspaces, Direct Sum.	12
Unit-II	**Vector Spaces-II:** Linear combination of Vectors, Linear independence and Linear dependence of Vectors. Finite dimensional Vector spaces, Basis, Existence theorem, Dimension of Vector Spaces.	8
Unit-III	**Linear Transformations I:** Linear transformations, linear operators, Properties of Linear Transformation, Algebra of Linear transformation, and composition of two linear transformations.	10
Unit-IV	**Linear Transformation II:** Null space and range of linear Transformation, Fundamental theorem of vector space homomorphism, Rank and Nullity Theorem, Matrix of linear transformation.	10
Unit-V	**Matrix:** Types of Matrices -Symmetric, Skew symmetric, Hermitian, Skew Hermitian, Orthogonal, Unitary and Normal matrices Elementary Properties of Matrices, Inverse of Matrices, Rank of Matrix, System of Linear Equations, Characteristic Equation, Eigenvalues and properties, Eigen vectors and properties, Cayley – Hamilton Theorem, Diagonolization.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Understand the notion of a vector space and linear transformation.
2. Determine basis and dimension of a vector space.
3. Find the characteristic polynomial and characteristic roots of a square matrix.

Learning Resources	
Text Book	1. B.V.S.S.Sarma, A text Book of B.Sc., Mathematics, S. Chand & Company Pvt. Ltd., New Delhi, 2nd Edition, 2013. 2. J.N. Sharma and A.R. Vasista, Linear Algebra, Krishna PrakashanMandir, Meerut, 1st Edition, 2015.
Reference Book and other materials	1. Shanti Narayana, A Book of Matrices, S. Chand & Company Pvt. Ltd., New Delhi, 2013. 2. Gilbert Strang and Ray Kunze, Linear Algebra, Pearson, 5th Edition, 2016. 3. Stephen H. Friedberg et al, Linear Algebra, Prentice Hall of India Pvt. Ltd. 4th Edition, 2007.

Course Code	Subject Name	L	T	P	C
19BMH0202	Ordinary Differential Equations	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. The course aims to introduce the basic differential Equal and gives a competency to solve them.
2. Enables the modeling of real life applications using differential equation.

UNIT	Course contents	Contact Hours
Unit-I	Basic definitions: Geometrical meaning of a differential equation,order and degree of differential equation, primitives, solutions of differential equations, Singular solutions,Exact differential equations, integrating factors, First order higher degree equations solvable for x,y,p Lagrange's equations, Clairaut's equations, Equation reducible to Clairaut's form.	10
Unit-II	Orthogonal trajectories: in Cartesian coordinates and polar coordinates,Self-orthogonal family of curves, linear differential equations with constant coefficients, Homogeneous linear ordinary differential equations, Equations reducible to homogeneous.	10
Unit-III	Linear differential equations of second order: Reduction to normal form, Transformation of the equation by changing the dependent variable/ the independent variable, Solution by operators of non-homogeneous linear differential equations.	10
Unit-IV	Reduction of order of a differential equation, Method of variations of parameters, Method of undetermined coefficients.	10
Unit-V	Ordinary simultaneous differential equations, Simultaneous equation of the form dx/P = dy/Q = dz/R, Total differential equations. Condition forPdx + Qdy +Rdz = 0 to be exact, General method of solving Pdx + Qdy + Rdz = 0 by taking one variable constant, Method of auxiliary equations.	10

LEARNING OUTCOME: After completion of the course the students will able to:

1. Distinguish between linear, nonlinear, partial and ordinary differential equations.
2. Recognize and solve a homogeneous differential equation and the exact differential equation.
3. Recognize and solve a linear differential equation by use of an integrating factor.
4. Solve basic application problems described by second order linear differential equations with constant coefficients.

Learning Resources	
Text Book	1. D.A. Murray: Introductory Course in Differential Equations. Orient Longman (India), 11th Edition, 2003. 2. E.A. Coddington: An Introduction to Ordinary Differential Equations. New York. 4th Edition, 2011. 3. S.L.Ross: Ordinary Differential Equations, Published by G. Bell, 4th Edition, 1982.
Reference Book and other materials	1. C. Henry Edwards and David E. Penney, Elementary Differential Equations with Boundary Value problem, 6th Edition, 2007. 2. H.T.H. Piaggio: Elementary Treatise on Differential Equations and their Applications. C.B.S. Publisher & Distributors, Delhi, 1st Edition, 1985.

SEMESTER III

Course Code	Subject Name	L	T	P	C
19BMH0301	Mechanics	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to equip the students with the knowledge of velocity, harmonic motion, constrained motion, Kepler's law, Motion of a particle in three dimensions and Forces in three dimensions.

UNIT	Course contents	Contact Hours
Unit-I	Velocity and acceleration along radial and transverse directions, and along tangential and normal directions, Simple harmonic motion, Motion under other laws of forces, Earth attraction, Elastic strings.	12
Unit-II	Motion in resisting medium, Constrained motion (circular and cycloidal only)	10
Unit-III	Motion on smooth and rough plane curves, Rocket motion, Central orbits and Kepler's law, Motion of a particle in three dimensions.	8
Unit-IV	Common catenary, Centre of gravity, Stable and unstable equilibrium, Virtual work.	10
Unit-V	Forces in three dimensions, Poinsot's central axis, Wrenches, Null line and null plane.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Analyze and explain the components of Velocity and acceleration.
2. Know the concept of different Motion in resisting medium.
3. Classify the Motion on smooth and rough plane curves and Rocket motion.
4. Define Common catenary, Centre of gravity.
5. Identify and describe Forces in three dimensions.

Learning Resources	
Text Book	1. Knadu Cohen, Fluid Mechanics, Elsevier India, 6th Edition, 2016.
Reference Book and other materials	1. S.L. Loney, an Elementary Treatise on Statics, Kalyani Publishers, New Delhi, 1st Edition 1971. 2. J.L. Synge, B.A. Griffith, Principles of Mechanics, McGraw-Hill, 2nd Edition, 1959. 3. P. Duraipandian, LaxmiDuraipandian and MuthamizhJayapragasam, Mechanics, S.Chand& Company PVT, LTD, 2014.

Course Code	Subject Name	L	T	P	C
20BMH0302	Theory of equations	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course gives the knowledge of general properties of polynomials general properties of equations, applications of symmetric function and solution of numerical equations.

UNIT	Course contents	Contact Hours
Unit-I	General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of polynomials	10
Unit-II	General properties of equations, Descartes' rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.	10
Unit-III	Symmetric functions, Applications of symmetric function of the roots, Transformation of equations, Solutions of reciprocal and binomial equations, Algebraic solutions of the cubic and biquadratic, Properties of the derived functions.	10
Unit-IV	Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.	10
Unit-V	Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic, Solution of numerical equations.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Analyze and explain the notion of polynomials and equations.
2. Know the concept of symmetric functions.
3. Classify the algebraic equations.
4. Find the roots of equations.
5. Know Newton's theorem and Strums theorem.

Learning Resources	
Text Book	1. W.S. Burnside and A.W. Panton, the Theory of Equations, Nabu Press, 2011. 2. T.K.Manickavachagam Pillai, Matrices, S.Viswanathan Printers & Publishers, 2012.
Reference Book and other materials	1. C. C. Mac Duffee, Theory of Equations, Dover Publications Inc., 2002. 2. P. Duraipandian, Trigonometry, Emerald publishers, 2009. 3. Birkhoff G., and S. Mac Lane, A Survey of Modern Algebra, CRC Press; 1 edition, 2008. 4. Lewis, and Papadimitriou, Elements of the Theory of Computation, Pearson; 1 edition, 1981

Course Code	Subject Name	L	T	P	C
19BMH0303	Operations Research I	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course introduces the fundamentals of Operations Research Models including linear programming and applications.
2. Students will learn how to construct models appropriate to particular applications and develop optimal solutions.

UNIT	Course contents	Contact Hours
Unit-I	Linear programming problems, Statement and formation of general linear programming problems, Graphical method, slack, and surplus variables, Standard and matrix forms of linear programming problem, Basic feasible solution.	12
Unit-II	Convex sets, Fundamental theorem of linear programming, Simplex method, artificial variables, Big-M method, two phase method.	8
Unit-III	Resolution of degeneracy, Revised simplex method, Sensitivity Analysis.	10
Unit-IV	Duality in linear programming problems, Dual simplex method, Primal-dual method.	10
Unit-V	Transportation problems: North West corner rule, least cost method, Vogel's approximation method, Modi method, unbalanced and degeneracy, Assignment problems: maximal assignment problem and travelling salesman problem.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Define and formulate linear programming problems and appreciate their limitations.
2. Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained and translate solutions into directives for action.
3. Conduct and interpret post-optimal and sensitivity analysis and explain the primal-dual relationship.
4. Develop mathematical skills to analyze and solve transportation problem with a wide range of applications.

Learning Resources	
Text Book	1. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 8th Ed., Tata McGraw Hill, Singapore, 10th Edition, 2015. 2. Hamdy A. Taha, Operations Research, An Introduction, 9th Ed., Prentice-Hall India, 9th Edition, 2018.
Reference Book and other materials	3. Gupta P. K., Hera D. S., Operations Research, S. Chand & Company Pvt. Ltd., New Delhi, 7th Edition, 2014. 4. S.D. Sharma, Operations research: Theory, methods and applications, KedarNath, RamnathPublications Meerut 2015. 5. V.Sundaresan, K.S.Ganapathy Subramanian &K.Ganesan, Resource Management Techniques, AR Publications, Chennai, 2015.

Course Code	Subject Name	L	T	P	C
19BMH0304	Multivariate Calculus	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: The course introduces the calculus for several variables to understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables.
This module also gives the knowledge of curves in three dimensional spaces.

UNIT	Course contents	Contact Hours
Unit-I	Functions of several variables, limit and continuity of functions of two variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability, Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes.	10
Unit-II	Extreme of functions of two variables, method of Lagrange multipliers, constrained optimization problems.	10
Unit-III	Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates.	10
Unit-IV	Triple integrals, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, cylindrical and spherical coordinates, Change of variables in double integrals and triple integrals.	10
Unit-V	Curves in three dimensional spaces: Curves in three dimensional spaces, Tangent vector, Normal plane and osculating plane, Normal plane at a point and fundamental planes, Orthonormal triad of unit vectors.	10

LEARNING OUTCOME:
Upon completing this course, students will able to:
1. Understand the conceptual variations when advancing in calculus from one variable to multivariable discussions.
2. Know Inter-relationship amongst the line integral, double and triple integral formulations.
3. Apply of multi variable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

Learning Resources	
Text Book	1. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling,Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007. 2. Shanti Narayan, Differential Calculus, Shyamlal Charitable Trust, New Delhi, 2001.
Reference Book and other materials	3. Murray Spigiel and Robert Wrede, Shaums Outline of Advanced Calculus, 3 rd Edition, Tata McGraw Hill Company, New Delhi, 2010. 4. G.V. Thomas and R.L. Finney, Calculus, Pearson Education, 9th Edition, 2006.

SEMESTER IV

Course Code	Subject Name	L	T	P	C
19BMH0401	Complex Analysis	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course aims to introduce the basic ideas of analysis for complex functions in complex variables.
2. The course explains Analytic function, Contour integration, Cauchy integral formula and Convergence of sequences and series.

UNIT	Course contents	Contact Hours
Unit-I	Limits, Limits involving the point at infinity, continuity, Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings, Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.	10
Unit-II	Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions.	10
Unit-III	Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals, Cauchy-Goursat theorem, Cauchy integral formula, An extension of Cauchy integral formula, consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.	10
Unit-IV	Convergence of sequences and series, Taylor series and its example, Laurent series and its examples, absolute and uniform convergence of power series, uniqueness of series representations of power series.	10
Unit-V	Zero of analytic functions, singular points, Residue at pole, residue at infinity, Method of finding residue, Residue formula, Cauchy Residue theorem.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Understand the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations.
2. Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.

Learning Resources	
Text Book	1. James Brown and Ruel V. Churchill, Complex Variables and Applications, McGraw-Hill Education, 2013.
Reference Book and other materials	1. BakJoseph and Newman Donald J., Complex analysis (Undergraduate Texts in Mathematics), Springer-Verlag New York Inc, 2010. 2. M. J. Ablowitz and A. S. Fokas, Complex Variables: Introduction and Applications, Cambridge University Press, NY, 2003. 3. S. Ponnusamy Foundations of Complex Analysis, Narosa Publishing House, 2nd Edition, 2005.

Course Code	Subject Name	L	T	P	C
19BMH0402	Partial Differential Equations	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: This course includes a variety of methods to solve partial differential equations with basic applications to real life problems. It provides a solid foundation to further in mathematics, sciences and engineering through mathematical modeling.

UNIT	Course contents	Contact Hours
Unit-I	Introduction, classification, construction and geometrical interpretation of first order partial differential equations (PDE). Formation of PDE by elimination of arbitrary constants and by elimination of arbitrary functions.	10
Unit-II	General solution of first order PDE, canonical form of first order PDE, method of separation of variables for first order PDE,Linear partial differential equation of order one.	10
Unit-III	Nonlinear partial differential equations of order one and its solutions, Charpit's method, Clairaut'sequations.Homogeneousand Non – Homogeneous partial differential equations of second and higher order with constant coefficients.	10
Unit-IV	Method of separation of variables for second order PDE, boundary value problems, One Dimensional wave equation,two dimensional wave equation, One dimensional heat equation, two dimensional heat equation.	10
Unit-V	General solution of three dimensional wave equations, General solution of three dimensional Laplace equations. Problem based on telegraph or transmission line equation.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Analyze real-world scenarios to recognize when partial differential equations are appropriate for creating an appropriate model.
2. Reduce a higher order equation to a system of first order simultaneous equations
3. Apply methods of solving higher-order linear differential equations
4. Perform methods for separation of variables, boundary value problems.

Learning Resources	
Text Book	1. K. S. Rao, Introduction to Partial Differential Equations, Prentice Hall India, 2006.
Reference Book and other materials	1. T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, 2nd Edition., 2012 2. LokenathDebnath, TynMyint-U, Linear Partial Differential Equation for Scientists and Engineers, Springer, 2008. 3. StavroulakisIoannis P Et Al , Partial Differential Equations: An Introduction with Mathematica and MAPLE, World Scientific Publishing Company, 2004.

Course Code	Subject Name	L	T	P	C
20BMH0403	Analysis I	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: The course aims to develop a deep and rigorous understanding of the real line and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. This concept has a wide range of applications in real life scenario.

UNIT	Course contents	Contact Hours
Unit-I	Real Number System, Algebraic and order properties of real , Absolute value of a real number; Boundedness of the set of real numbers; least upper bound, greatest lower bound of a set,Supremumandinfimum of a nonempty subset of R.	10
Unit-II	The completeness property of R, Archimedean property, Density of rational numbers in R; Definition and types of intervals, Nested intervals property; Neighborhood of a point in R, Open and closed sets in R, interior points, isolated points, limit points, open sets, closed set, interior of a set,Closure of a set in real numbers and their properties.	10
Unit-III	Sequence: Real Sequences and their convergence, Theorem on limits of sequence, Bounded and Monotonic sequences, Cauchy's sequence, Cauchy general principle of convergence, Subsequence's, Sub sequential limits	10
Unit-IV	Infinite series:Convergence and divergence of Infinite Series,ComparisonTests, D-Alembert's ratio test, Raabe's test, Logarithmic test, de Morgan and Bertrand'stest, Cauchy's Nth root test, Gauss Test, Cauchy's integral test, Cauchy's condensation test.Alternating series, Leibnitz's test, absolute and conditional convergence of an alternating series.	10
Unit-V	Limit and Continuity of functions: Limits of functions (epsilon-delta approach), Infinite limits & limits at infinity, Algebra of limits of functions. Continuous functions: continuity & discontinuity of a function, Bounds of a function, Theorems on continuous functions, Monotonic functions,and Uniform continuity of a function.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Understand many properties of the real line
2. Define a sequence in terms of functions from N to a subset of real line.
3. Recognize bounded, convergent, divergent, Cauchy and monotonic sequences
4. Calculate their limit superior, limit inferior, and the limit of a bounded sequence.

Learning Resources	
Text Book	1. S. C. Malik, Savita Arora, Mathematical analysis, New Age International, 2009.
Reference Book and other materials	1. Donald R. Sherbert Robert G. Bartle , Introduction to real analysis, Wiley, 2014. 2. R.R. Goldberg, Methods of Real Analysis, Oxford & I.B.H. Publishing Co., 2012. 3. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 2002.

Course Code	Subject Name	L	T	P	C
20BMH0404	Probability and Statistical Methods	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. The course aims to make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.
2. The course intends to render the students to several examples and exercises that blend their everyday experiences with their scientific interests.

UNIT	Course contents	Contact Hours
Unit-I	Importance of statistics, concepts of statistical population and a sample – quantitative and qualitative data – Collection of primary and secondary data. Designing a questionnaire and a schedule. Classification and tabulation of data. Measurement scales –nominal, ordinal, interval and ratio. Diagrammatic and Graphical representation of data. Construction of univariate and bivariate frequency distributions. Stem and leaf plot.	11
Unit-II	Concept of central tendency, Partition values and dispersion, Box plot. Measures of inequality – Gini's Coefficient and Lorenz curve. Skew-ness, kurtosis and their measures based on quartiles and moments.	10
Unit-III	Random experiment, definition of probability, classical and relative frequency approach to probability, axiomatic approach to probability and its properties, merits and demerits of these approaches, total and compound probability, conditional probability theorems, independence of events, Bayes theorem and its applications.	9
Unit-IV	Random Variable: Concept of discrete random variable, probability mass function and distribution function, joint probability mass function of several discrete random variables, marginal and conditional probability mass functions. Continuous random variable: Probability density function, distribution function.	10
Unit-V	Two dimensional Random Variables - Marginal and conditional distributions - Transformation of Random Variables. Joint density function of two continuous variables, marginal and conditional probability density functions. Central limit theorem (for independent and identically distributed random variables).	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Study the basics of data and graphs in statistics.
2. Study the measures of central tendency and dispersion.
3. Study the behavior of random variable and two dimensional random variable.

Learning Resources	
Text Book	1. S.C Gupta & V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th edition, Sultan chand& sons, reprint, 2007.
Reference Book and other materials	1. Mood A.M., Greybill F.A. and Bose D.C., Introduction to the Theory of Statistics, McGraw Hill, 3th Edition, 1974. 2. Goon A.M., Gupta M.K. and Das Gupta B., Fundamental of Statistics, Vol. I, World Press Private Ltd, 2013. 3. P. R. Vittal, Mathematical Statistics, Margham Publications, Chennai, 2013.

SEMESTER V

Course Code	Subject Name	L	T	P	C
19BMH0501	Numerical Methods	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aim is to teach the student various topics in Numerical Analysis such as solutions of nonlinear equations in one variable, interpolation and approximation, numerical differentiation and integration, direct methods for solving linear systems, numerical solution of ODE.

UNIT	Course contents	Contact Hours
Unit-I	Errors: Round off error, Local truncation error, Global truncation error, Order of a method, Convergence and terminal conditions, Efficient computations Bisection method, Secant method, RegulaFalsi method, Newton Raphson method, Newton's method for solving nonlinear systems.	12
Unit-II	First and Higher order differences, Forward differences and backward differences and Central Differences, Differences of a polynomial, Properties of operators, Factorial polynomials, Shifting operator E, Relations between the operators, Finding the missing terms and effect of error in a difference tabular values.	8
Unit-III	Interpolation with equal intervals, Newton's forward and Newton's backward interpolation formulae, Interpolation with unequal intervals, Newton's divided difference, Lagrange s Interpolation formulae, Hermite Formula, Central Differences, Gauss forward and Gauss backward interpolation formulae, Sterling, Bessel Formula.	10
Unit-IV	Numerical Differentiation: Derivative of a function using interpolation formulae as studied in above interpolation methods, Numerical Integration, Newton-Cote's Quadrature formula, Trapezoidal rule, Simpson's one- third and three-eighth rule, Chebychev formula, Gauss Quadrature formula.	10
Unit-V	Numerical solution of ordinary differential equations, Single step methods-Picard's method, Taylor's series method, Euler's method, Runge-KuttaMethods(II&IV), Multiple step methods, Predictor-corrector method, Modified Euler's & Milne method	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Understand the nature and operations of Numerical Analysis and demonstrate familiarity with different concepts and find numerical roots of equations by different methods
2. Identify the suitable computational technique for a specific type of problems and develop the computational method that is suitable for the underlying problem.

Learning Resources	
Text Book	1. Shastry, S.S, Introductory methods of numerical methods, Prentice-Hall Ltd, 4th Edition 2004. 2. Jam, Iyengar, S.R.K. and Jain R.K., Numerical methods for Scientific and Engineering Computation – New Age Publishers, 1987.
Reference Book and other materials	1. Robert M. Corless and Nicolas Fillion, A graduate introduction to numerical methods,Springer International, 2013 2. Venkatraman, M.K., Numerical Methods in Science and Engineering, National publishing Company – Chennai, 5th Edition 1995.

Course Code	Subject Name	L	T	P	C
20BMH0502	Analysis II	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: The course aims to make the students familiar with the concepts of Riemann integral, Improper integrals, sequence and series of functions and their convergence.

UNIT	Course contents	Contact Hours
Unit-I	The derivative and Mean Value Theorem: Derivability, Rolle's Theorem, Lagrange's Mean value theorem, Heigher order Derivatives, Taylor's theorem with Lagrange's form of remainder, Maclaurin'stheorem, Taylor's series &Maclaurin's series expansions of exponential & trigonometric functions.	10
Unit-II	Arbitrary series: abel'slemma, Abel's test, Dirichlet's test, Insertion and removal of parenthesis, re-arrangement ofterms in a series, Dirichlet's theorem, Riemann's Re-arrangement theorem, Cauchy product of series (definitions andexamples only), Convergence and absolute convergence of infinite products.	10
Unit-III	Riemann Integration, Darboux's Theorem, The integral as a sum of limit of sums, Properties of Riemann integral, Continuity and differentiability of integrable functions, The Fundamental theorem of integral calculus, and Mean value theorems of integral calculus.	10
Unit-IV	Countable and uncountable sets, Contor's set, Improper integrals of Type-I, Type-II and mixed type, Convergence of Beta and Gamma functions, and their properties.	10
Unit-V	Comparison tests, Abel's and Dirichlet's tests, Frullani's integral, Integral as a function of a parameter, Continuity, Differentiability and Inerrability of an integral of a function of a parameter.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Know the notion of Riemann integral and improper integral.
2. Perform Comparison tests, Abel's and Dirichlet's tests.
3. Describe the Functions of bounded variation.
4. Study about the Sequences and series of functions.

Learning Resources	
Text Book	1. W. Rudin: Principles of Mathematical Analysis, 3rd Edition. McGraw Hill, 1976. 2. S.C. Malik and Savita Arora: Mathematical Analysis, New Age International Publishers, Reprint 2005.
Reference Book and other materials	1. Tom M. Apostol: Mathematical Analysis, 2nd Edition. Narosa Publishing House, Reprint 2002. 2. R.R. Goldberg: Real analysis, Oxford & IBH publishing Co., New Delhi, 1970 3. B. Choudhary: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997.

Course Code	Subject Name	L	T	P	C
19BMH0503	Number Theory	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course intends to build a micro aptitude of understanding aesthetic aspects of mathematical instructions and gear young minds to ponder upon such problems.
2. Also, another objective is to make the students familiar with simple number theoretic techniques, to be used in data security.

UNIT	Course contents	Contact Hours
Unit-I	Divisibility Theory in the Integers: The Division Algorithm, The Greatest Common Divisor, Residue classes and reduced residue classes.	11
Unit-II	The Euclidean Algorithm, The Diophantine Equation ax+by=c, The Fundamental Theorem of Arithmetic.	9
Unit-III	FermatsTheorem: Fermat Little Theorem and Pseudo primes, Wilsons Theorem, The FermatKraitchik Factorization Method.	10
Unit-IV	The Theory of Congruence: Basic Properties of Congruence, Binary and Decimal Representation of Integers, Linear Congruence, the Chinese Remainder Theorem.	10
Unit-V	The Mobius Inversion Formula, The Legendre Symbol and Its Properties, Quadratic Reciprocity, The Equation x^2+y^2=z^2, Fermats Last Theorem.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Some of the open problems related to The Division Algorithm.
2. About The Euclidean Algorithm.
3. About The Fermat Kraitchik Factorization Method.
4. About Congruence Mobius Inversion Formula and Legendre Symbol with its properties.

Learning Resources	
Text Book	1. David M. Burton, Elementary Number Theory, Mcgraw Hill Education, 7th Edition, 2011.
Reference Book and other materials	1. Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery, an Introduction tothe Theory of Numbers, Wiley, 5th Edition, 1991. 2. Tom M. Apostol, Introduction to Analytic Number Theory, Springer, 1st Edition, 1976. 3. G. H. Hardy, An introduction to the theory of Numbers, Clays Ltd, St lvesplc, 6th Edition 2008. 4. Ireland, Kenneth, Rosen, Michael, a Classical Introduction to Modern Number Theory, New York, NY: Springer New York, 1990.

SEMESTER VI

Course Code	Subject Name	L	T	P	C
19BMH0601	Metric Spaces	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: The course aims to provide the basic knowledge pertaining to metric spaces such as open and closed balls, neighborhood, interior, closure, subspace, continuity, compactness, connectedness etc.

UNIT	Course contents	Contact Hours
Unit-I	Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces.	9
Unit-II	Open and closed balls, neighborhood, open set, interior of a set, Limit point of a set, closed set, diameter of a set, Cantor's Theorem, Subspaces, dense sets, separable spaces.	10
Unit-III	Continuous mappings, sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mappings, Banach Fixed point Theorem.	9
Unit-IV	Connectedness, connected subsets of R, connectedness and continuous mappings.	8
Unit-V	Compactness, compactness and boundedness, continuous functions on compact spaces.	9

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Understand the basic concepts of metric spaces.
2. Correlate these concepts to their counter parts in real analysis.
3. Appreciate the abstractness of the concepts such as open balls, closed balls, compactness, connectedness etc.

Learning Resources	
Text Book	1. SatishShirali&Harikishan L. Vasudeva, Metric Spaces, Springer Verlag London, 2006. 2. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition, Major CoreGraw–Hill International Editions, Singapore, Reprint 2012.
Reference Book and other materials	1. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, Second Edition 2011. 2. G. F. Simmons, Introduction to Topology and Modern Analysis, Mcgraw-Hill, Edition 2004. 3. Richard R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Co, Pvt. Ltd., New Delhi, 2010.

Course Code	Subject Name	L	T	P	C
19BMH0602	Vector Analysis	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. The course aims to introduce and develop the methods of vector analysis, vector differentiation, and vector integration.
2. These are used as a fundamental tool in many theories of applied mathematics.

UNIT	Course contents	Contact Hours
Unit-I	Vector Algebra and Geometry: Vector addition and scalar multiplication, Scalar and vector products, Equations of lines and planes, Curves and surfaces; parametric and non-parametric equations of curves and surfaces.	9
Unit-II	Vector Differentiation: Differentiation of vector valued functions with respect to a scalar, Geometry of curves, Scalar and vector fields, Gradient of a scalar field, and divergence and curl of a vector field, Sum and product rules for these differentiation operators, second order vector operators, Directional derivative, Normal and tangent plane to a surface,Solenoidal and irrotational fields.	11
Unit-III	Vector Integration: Curvilinear line integrals, Surface integrals, the divergence theorem, Green's theorem and Stoke's theorem.	8
Unit-IV	Curvilinear Coordinate system, coordinate free vector derivatives, Vector derivatives in curvilinear coordinates, Spherical, polar and cylindrical coordinates.	9
Unit-V	Potential Theory: Gradient fields, Rotation fields, Harmonic functions, Helmholtz's fundamental theorem of vector calculus.	8

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Calculate scalar and vector products and find the vector equations of lines and planes.
2. Understand the parametric equations of curves and surfaces.
3. Understand and be able to find the unit tangent vector, the unit principal normal and the curvature of a space curve.
4. Find the gradient of a function.
5. Find the gradient, divergence and curl of a vector field and prove identities.
6. Recognize irrotational and solenoidal vector fields and understand the various integral theorems

Learning Resources	
Text Book	1. S. Narayanan and T. K. Manickavachagam Pillai, Trigonometry, S. Viswanathan Printers & Publishers, (Reprint), 2012.
Reference Book and other materials	1. T. K. Manickavasagam Pillai, Natarajan and Ganapathy, Algebra, Volume II, S.Viswanathan Pvt. Ltd., 2004 2. Marsden, J., and Tromba, Vector Calculus, W. H. Freeman; 5th edition, 2003. 3. Courant, R, and F. John, Introduction to Calculus and Analysis, Volume II, Springer First Edition, 2004

Course Code	Subject Name	L	T	P	C
19BMH0603	Descriptive Statistics and Distribution Theory	4	1	0	5
CORE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. To course aims to make the students familiar with the basic statistical concepts of correlation, regression, multiple correlation, distributions and some statistical tests.
2. The course intends to render the students to several examples and exercises that blend their everyday experiences with their scientific interests.

UNIT	Course contents	Contact Hours
Unit-I	Bivariate data: Scatter diagram, product moment correlation coefficient and its properties, coefficient of determination, correlation ratio, interclass correlation, and concept of error in regression, principle of least squares, fitting of linear regression and related results, rank correlation.	10
Unit-II	Partial and multiple correlation in three variables, their measures and related results, Theory of attributes, Independence and Association of attributes, various measures of association for two way and three way classified data.	10
Unit-III	Expectation of random variable and its properties, conditional expectation, moment in terms of expectation, moment generating function of a random variable, their properties and uses, probability generating function, Tchebycheff's inequality and its applications, convergence in probability and in distribution.	10
Unit-IV	Standard discrete and continuous distributions, Uniform, Binomial, Poisson, geometric, negative Binomial, hypergeometric, normal, beta, gamma, and Bivariate Normal distributions.	10
Unit-V	Large sample tests based on Normal Distribution – Small sample tests based on t, F distributions – Chi square tests for goodness of fit and independence of attributes.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Study the correlation, regression and multiple correlation.
2. Study moment generating functions and convergence.
3. Study the basics of probability distribution (discrete and continuous).
4. Study the statistical tests with applications.

Learning Resources	
Text Book	1. Rohtagi V.K., An Introduction to Probability Theory and Mathematical Statistics, John Wiley and Sons, Online Edition, 2015.
Reference Book and other materials	1. A.M.Goon, A.K. Gupta and B.Das Gupta, Fundamental of Statistics, World Press, 2016. 2. Mood A.M., Greybill, F.A. and Bose D.C., Introduction to the Theory of Statistics, McGraw Hill, 3rd Edition, 1974. 3. Hogg R.V. and Craig A.T., Introduction to Mathematical Statistics, Amerind Publishing Co, 7th Edition, 2012. 4. Hoel P.G., Introduction to Mathematical Statistics, Asia Publishing House, 2nd Edition, 1984.

Generic Elective – I:

Course Code	Subject Name	L	T	P	C
20GEPH101	Physics I-Waves & Optics	3	0	0	3
GE	Pre-requisite				
	Co-requisite				
	Designed by Physics Department				

COURSE OBJECTIVE:

1. To develop an understanding of waves and to learn about SHM.
2. To understand fundamental concepts of optics and characteristics of light.

UNIT	Course contents	Contact Hours
Unit-I	**WAVES MOTION:** Simple Harmonic Motion (SHM), Differential Equation of SHM. Simple Harmonic Oscillations of loaded spring. Concepts of Free, Dampled, Undamped and Forced vibrations. Resonance and Quality factor. Wave motion-Characteristics, Properties of Transverse &Longitudnal Wave motion. Relation between frequency and wavelength.	8
Unit-II	**NON-DISPERSIVE WAVES:** Non-dispersive transverse and longitudinal waves: Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their Eigen frequencies, longitudinal waves and the wave equation for them, acoustics waves.	7
Unit-III	**OPTICAL INTERFERENCE**: Huygens ' Principle, Young's double slit experiment, Superposition of waves, Theory of interference, Conditions for sustained interference, Interference in parallel and wedge shaped films, Colour of thin films, Newton's rings and Mach Zehnder interferometer and their applications.	7
Unit-IV	**OPTICAL DIFFRACTION:**Frenel's diffraction, Zone plate, Diffraction due to straight edge. Fraunhoffer diffraction due to circular aperture, single and double slits, Plane transmission grating and its resolving power. The Rayleigh criterion for limit of resolution.	8
Unit-V	**LASERS & FIBER OPTICS:** Lasers-Einstein Coefficients, Population Inversion, Principles and characteristics of Laser-Directionality, Coherence, Intensity, Types of Lasers- HeNe, Nd: YAG, CO2 laser. Optical Fiber: Principles-Physical structure, Wave guide parameter (V-Number), Optical Fiber Types: Multi mode and single mode optical fibers. Optical Fiber Profiles-Step Index & Parabolic Index,	7

LEARNING OUTCOME:

1. To appreciate that wave can be of several kind e.g. Sound and light
2. To know basic properties and phenomena exhibited by light wave

Learning Resources	
Text Book	1. Subrahmanyam N., BrijLal, Waves and Oscillations, Vikas Publishing House, 2nd Revised Edition, 2011. 2. N. Bajaj , The Physics of Waves and Oscillations, Tata McGraw-Hill Education Pvt. Ltd.,1st Edition, 2004
Reference Book and other materials	1. Subrahmanyam N., Brijlal and Avadhanulu M. N., A textbook of Optics,SChand Publications, 2012. **2.** Pandey B.K. andChaturvedi S., Engineering Physics, Cengage Learning, New Delhi, 1st Edition, 2012.

Course Code	Subject Name	L	T	P	C
20GEPH103	Physics Laboratory-I	0	0	2	1
GE	Pre-requisite				
	Co-requisite				
	Designed by Physics Department				

Note: Students must perform at least 6 out of 8 experiments

Experiment	Name of Experiment
Experiment 1	To measure dimensions precisely with the help of the VernierCallipers and Screw Gauge and to determine density of a given solid.
Experiment 2	To determine the angle & dispersive power of a given prism
Experiment 3	To determine the wavelength of sodium light by Michelson Interferometer Experiment
Experiment 4	To study diffraction pattern of single and double slit.
Experiment 5	To determine the wavelength of the given laser source using standard grating
Experiment 6	To determine the attenuation, numerical aperture and acceptance angle of the given optical fiber.
Experiment 7	To determine the moment of inertia of the disc and rigidity modulus of the material of the wire by torsional oscillations
Experiment 8	To determine the wavelength of sodium light by Newton's ring experiment

Learning Resources	
Text Book	1. Chattopadhyay, D., Rakshit, P. C and Saha, B., "An advanced Course in Practical Physics", 2nd edition, Books & Allied Ltd, Calcutta, 1990.
Reference Book and other materials	1. Chauhan and Singh , " Advanced practical physics", Revised edition, PragatiPrakashan Meerut, 1985. **2.** Thiruvadigal. J. D., Ponnusamy S. Vasuhi, P. S. and Kumar. C, "Hand Book of Practical physics", 5th edition, Vibrant Publication, Chennai, 2007.

Course Code	Subject Name	L	T	P	C
CYG-101	Physical Chemistry	3	0	0	3
GE	Pre-requisite				
	Co-requisite				
	Designed by Chemistry Department				

COURSE OBJECTIVE:

1. This course provides fundamental knowledge of physical chemistry.
2. Further, this course focuses on Thermodynamics, Kinetic Theory of Gases, Nuclear & solid state chemistry and related applications.

UNIT	Course contents	Contact Hours
Unit-I	**Thermodynamics:** Intensive and extensive variables; state and path functions; isolated, closed and open systems. Concept of heat Q, work W, internal energy U, and statement of first law; enthalpy H, relation between heat capacities, calculations of Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.	8
Unit-II	**Second Law:** Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics. Calculation of entropy change for reversible and irreversible processes. Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations.	6
Unit-III	**Second Law:** Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics. Calculation of entropy change for reversible and irreversible processes. Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations.	7
Unit-IV	**Nuclear Chemistry:** Fundamentals of radioactivity and decay, preparation of radioisotopes for tracers, applications with radiotracers, radiometric titration, radioactivity measurements by gas filled and scintillation detectors. Radioactive decay, decay kinetics, parent daughter decay growth relationship, concepts of transient and secular equilibrium, alpha, beta and gamma decay, artificial radioactivity.	7
Unit-V	**Solid Chemistry:** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method.	7

LEARNING OUTCOME:

Provide a broad foundation in chemistry that stresses scientific reasoning and Analytical problem solving with a molecular perspective.

1. Achieve the skills required to succeed in graduate school, the chemical industry and professional school.
2. Understand the importance of the Periodic Table of the Elements, how it came to be, and its role in organizing chemical information.
3. Understand the interdisciplinary nature of chemistry and to integrate knowledge of mathematics, physics and other disciplines to a wide variety of chemical problems.
4. Learn the laboratory skills needed to design, safely and interpret chemical research.
5. Learn professionalism, including the ability to work in teams and apply basic ethical principles

Learning Resources	
Text Book	1. Atkins P.; Paula, Keeler J., Physical Chemistry, Oxford, 11th Edition, 2017 2. Cheetham A. K. and Day P., Solid state chemistry compounds, Clarendon Press, Oxford, 1st Edition, 1992.
Reference Book and other materials	1. West R., Solid state chemistry and its applications, John Wiley & Sons,2nd Edition,2014. **2.** Rao C. N. R. and Gopalakrishanan J., new directions in solid state chemistry, Cambridge Univ. Press, 2nd Edition 1997.

Course Code	Subject Name	L	T	P	C
CYG-101L	Physical Chemistry Practical	0	0	2	1
GE	Pre-requisite				
	Co-requisite				
	Designed by Chemistry Department				

Experiment	Name of Experiment
Experiment 1	Conduct metric titrations: Strong acid vs. strong base; Weak acid vs. strong base.
Experiment 2	Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
Experiment 3	Study the kinetics of the following reactions. i. Saponification of ethyl acetate. ii. Comparison of the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.
Experiment 4	Interpretation of a given powder diffraction pattern of a cubic crystalline system. (a) Determination of heat capacity of a calorimeter for different volumes using (i) Change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulfuric acid or enthalpy of neutralization) (b) (ii) Verification of heat law.
Experiment 5	a) Determination of heat capacity of a calorimeter for different volumes using (i) Change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulfuric acid or enthalpy of neutralization) b) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide. c) Determination of the enthalpy of ionization of ethanoic acid. d) Determination of integral enthalpy (endothermic and exothermic) solution of salts.

Learning Resources	
Text Book	1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi, 2011. 2. Ahluwalia, V. K.;Dhingra, S.;Dhingra,S. College Practical Chemistry, Universities Press, 2005.
Reference Book and other materials	1. Pandey, O.P.;Bajpai,D. N.; Giri,S.Practical Chemistry, S. Chand Limited, Revised Edition, 2014. 2. Vogel A.I.: Qualitative Inorganic Analysis, Prentice Hall, 7th Edition,1996. **3.** Atkins P.; Paula, Keeler J., Physical Chemistry, Oxford, 11th Edition, 2017.

Course Code	Subject Name	L	T	P	C
19BMH0103	Operating Systems	3	0	0	3
GE	Pre-requisite				
	Co-requisite				
	Designed by Computer Science and Technology				

COURSE OBJECTIVE:

1. Every computer professional should have a basic understanding of how an operating system controls the computing resources and provide services to the users.
2. This course provides an introduction to the operating system functions, design and implementation.
3. It serves as a strong foundation for other courses like networks, compiler design, database systems.

UNIT	Course contents	Contact Hours
Unit-I	**INTRODUCTION:** Operating system overview-objectives and functions, Concept of Multitasking, multiprogramming, multi user, Multithreading etc., Types of Operating Systems; Various Operating system services, architecture, System programs and calls.	9
Unit-II	**PROCESSES & SCHEDULING:** Process concept, process scheduling, operation on processes; CPU scheduling, scheduling criteria, scheduling algorithms.	8
Unit-III	**CONCURRENCY:** Principles of concurrency - mutual exclusion, semaphores, monitors, Readers/Writers problem; Deadlocks– prevention-avoidance – detection	9
Unit-IV	**MEMORY:** Logical & Physical Address Space, swapping, contiguous memory allocation, noncontiguous memory allocation paging and segmentation techniques, segmentation with paging; virtual memory management - Demand Paging & Page-Replacement Algorithms; Demand Segmentation.	8
Unit-V	**INPUT/OUTPUT AND FILE SYSTEMS:** I/O management and disk scheduling – I/O devices, organization of I/O functions; OS design issues, I/O buffering, disk scheduling, Disk cache, File management – organization, directories, file sharing, record blocking, secondary storage management.	8

LEARNING OUTCOME:

On completion of this course, the students will be able to

1. Explain basic operating system concepts such as overall architecture, interrupts, APIs, user mode and kernel mode.
2. Distinguish concepts related to concurrency including, synchronization primitives, race conditions, critical sections and multi-threading.
3. Analyze and apply CPU scheduling algorithms, deadlock detection and prevention algorithms.

4. Examine and categories various memory management techniques like caching, paging, segmentation, virtual memory, and thrashing.

Learning Resources	
Text Book	1. William Stallings, "Operating Systems – internals and design principles", Prentice Hall India, 5th Edition, 2005. 2. Silberschatz, Peter Galvin, "Operating System Concepts", AWL 6th Edition, 2002,
Reference Book and other materials	1. Andrew S. Tannenbaum & Albert S. Woodhull, "Operating System Design and Implementation", Prentice Hall India, 2nd Edition, 1998. **2.** Gary Nutt, "Operating System - A Modern Perspective", Pearson Education Asia, 2nd Edition 2000

Course Code	Subject Name	L	T	P	C
19BMH0103L	Operating Systems Lab	0	0	2	1
GE	Pre-requisite				
	Co-requisite				
	Designed by Computer Science and Technology				

COURSE OBJECTIVE: This laboratory course gives a complete understanding of the operating systems principles and its implementations.

Experiment	Name of Experiment
Experiment 1	Write a program to implement CPU scheduling for first come first serve.
Experiment 2	Write a program to implement CPU scheduling for shortest job first.
Experiment 3	Write a program to perform priority scheduling.
Experiment 4	Write a program to implement CPU scheduling for Round Robin.
Experiment 5	Write a program for page replacement policy using a LRU
Experiment 6	Write a program for page replacement policy using FIFO
Experiment 7	Write a program for page replacement policy using Optimal.
Experiment 8	Write a program to implement first fit, best fit and worst fit algorithm for Memory management.
Experiment 9	Write a program to implement reader/writer problem using semaphore.
Experiment 10	Write a program to implement Banker's algorithm for deadlock avoidance.

LEARNING OUTCOMES:

On completion of this course, the students will be able to

1. Scheduling algorithms
2. Deadlock algorithms and page replacement algorithms
3. Memory management schemes, Thread and synchronization

Learning Resources	
Text Book	Laboratory Manual
Reference Book and other materials	Laboratory Manual

Skill Enhancement Course – I

Course Code	Subject Name	L	T	P	C
20BMH 0104	Programming in C++	2	0	0	2
SEC	Pre-requisite				
	Co-requisite				
	Designed by Computer Science and Technology				

COURSE OBJECTIVE:

1. This course provides fundamental knowledge of C++ Programming paradigms.
2. Further this course focuses on basics of C++, Exception Handling and I/O, Polymorphism, Programming paradigms, object and a class, interface and implementation of a class.

UNIT	Course contents	Contact Hours
Unit-I	Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer.	6
Unit-II	Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.	6
Unit-III	Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.	6
Unit-IV	Basics of C++ Exception Handling: Try Throw, Catch, Throwing an Exception;- Catching an Exception, Re-throwing an Exception, Processing Unexpected Exceptions.	6
Unit-V	Files and I/O Streams and various operations on files. Stream Input/output Classes and Objects, Stream Output, Stream Input, Unformatted I/O (with read and write).	6

LEARNING OUTCOME:

On completion of this course, the students will be able to

1. Explain basic operating system concepts such as overall architecture, interrupts, APIs, user mode and kernel mode.
2. Distinguish concepts related to concurrency including, synchronization primitives, race conditions, critical sections and multi-threading.
3. Analyze and apply CPU scheduling algorithms, deadlock detection and prevention algorithms.
4. Examine and categories various memory management techniques like caching, paging, segmentation, virtual memory, and thrashing.

Learning Resources	
Text Book	1. E. Balagurusamy , Object oriented Programming with C++, 3rd Edition, , Tata McGraw-Hill Education, 2006.
Reference Book and other materials	1. C. S. Horstmann, Computing Concepts with C++ Essentials, 3rd Edition, John Wiley & Sons Inc. 2003. 2. K. R. Venugopal and Rajkumar, Mastering C++, Tata Mcgraw Hill Education Private Limited, 2nd edition, January 2013.

Course Code	Subject Name	L	T	P	C
20BMH0104L	C++ Programming Lab	0	0	2	1
SEC	Pre-requisite				
	Co-requisite				
	Designed by Computer Science and Technology				

Experiment	Name of Experiment
Experiment 1	Write a C++ program to implement the concept Arrays of Objects
Experiment 2	Create Class ‘student’, create an array of students, find out the student who get the first rank.
Experiment 3	Write a C++ program to implement operator overloading to perform complex arithmetic.
Experiment 4	Write a program that uses a class where the member functions are defined inside a class.
Experiment 5	Write a program that uses a class where the member functions are defined outside a class.
Experiment 6	Write a program to demonstrate the use of static data members.
Experiment 7	Write a program to demonstrate the use of dynamic constructor.
Experiment 8	Write a program to demonstrate the use of explicit constructor.
Experiment 9	Write a program to demonstrate the overloading of increment and decrement operators
Experiment 10	Write a program to demonstrate the overloading of binary arithmetic operators.
Experiment 11	Write a program to demonstrate the overloading of memory management operators.
Experiment 12	Write a program to demonstrate the typecasting of basic type to class type.
Experiment 13	Write a program to demonstrate the multilevel inheritance.
Experiment 14	Write a program to demonstrate the virtual derivation of a class.

Learning Resources	
Text Book	Laboratory Manual
Reference Book and other materials	Laboratory Manual

Course Code	Subject Name	L	T	P	C
19BMH0105	Programming with R	2	0	2	3
SEC	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course takes you from having no previous experience in programming to an intermediate level in R.
2. You will learn the basic toolkit of the data-oriented professional, and learn where and how to learn more advanced skills when needed.

UNIT	Course contents	Contact Hours
Unit-I	Basics of Programming: The purpose of this unit is to introduce programming with the eventual aim of developing skills required to write statistical software, Topics should include simple syntax, loops, arrays, functions, input/output, and linking to databases.	10
Unit-II	Numerical analysis and statistical applications: The purpose of this unit is to apply programming skills in methods and algorithms useful in probability, statistics, and data analysis.	10
Unit-III	Topics should include numerical integration, root extraction, random number generation, Monte Carlo integration, and matrix computations.	10
Unit-IV	Topics related to graphics, descriptive statistics, representation of multivariate data, simple hypothesis tests, analysis of variance.	10
Unit-V	Control structure, functions, lapply, tapply, split, mapply, scoping rules, debugging tools.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Implement empirical mathematical/ statistical analyses.
2. Participate in online data science challenges.
3. Learn on your own further R, or other programming languages.

Learning Resources	
Text Book	1. Seema Acharya, Data analytics using R, McGraw Hill Publications, 2018. 2. Jared P. Lander, R for everyone: Advanced Analytics and Graphics, Addison-Wesley, 2014.
Reference Book and other materials	1. Garrett Grolemund, Hand on Programming with R, 2016. 2. Acharya Seema, Data analytics using R, McGraw Hill Publications, 1st Edition, 2018. 3. Lander Jared P., R for everyone: Advanced Analytics and Graphics, Addison-Wesley, 2nd Edition, 2017.

Note: Practical's based on above syllabus.

Practical paper will be of 100 marks out of which 40 marks will be assigned on group discussions, practical record book and 60 marks will be assigned performance in practical's and viva – voce exam by the external examiner.

Ability Enhancement Compulsory Course – I

Course Code	Subject Name	L	T	P	C
20AEC0101	Communicative English	4	0	0	4
AECC	Pre-requisite				
	Co-requisite				
	Designed by English Department				

COURSE OBJECTIVE:

1. This course enhances and strengthens communication skills in English language facilitating the holistic and integrated development of LSRW skills – Listening, Speaking, and Reading Writing.
2. The course will expose the learners to a wide range of lexical and grammatical skills, critical reading and writing and professional communicative skills to meet the demands at workplace.

UNIT	Course contents	Contact Hours
Unit-I	**Grammar & Vocabulary Building:** Introduction - Basic English Grammar – Tenses – Active Voice Passive Voice Phrasal verbs – Prepositions - Building Vocabulary - Prefixes and Suffixes – Simple and complex sentences	8
Unit-II	**Basic Writing Skills:** Writing - Effective Language - Formal Letters, Memos & Email - letters to the editor - Writing letters, informal and official - Art of Condensation –Article Writing - Writing Proposals - Research Papers – Preparing Minutes of Meeting.	8
Unit-III	**Technical Writing Skills:** Report Writing: Scientific documents/observations/experimentsDiscipline specific writing techniques, vocabulary and practices, Curriculum Vitae – Resume, Writing Abstract and Synopsis, Writing Reviewing – Editing.	8
Unit-IV	**Communication:** English Communication - Aims & Objectives - Basics of Communication-Barriers to Communication-Non-Verbal Communication – Listening Skills - Active Listening - Effective Speaking – Speech - Art of Public Speaking – Pronunciation - Stress & Intonation in English – Debate – Conversations	8
Unit-V	**Effective Reading:** Reading strategies (Skimming, Scanning, Inferring) – Predicting and responding to content – Speed Reading – Note Making – Use of Extensive reading texts – Vocabulary Extension – Guessing from Context - Use of Extensive Reading Texts. **Language through Literature:** The Overcoat (Nikolai Gogol) The Open Window (H.H. Munro) To a Skylark (P.B. Shelley) The Raven (Edgar Allan Poe)	8

LEARNING OUTCOME:

After a successful completion of this course, the learners will be able to:

- Seamlessly communicate in standard English – written & spoken
- Analyse texts on various parameters expected/demanded during different situations and circumstances
- Conduct basic research on a topic (pertaining to their discipline/workplace)
- Prepare basic/preliminary research documents, official documents
- Prepare and deliver presentations on a given topic
- Understand and analyse the time, history, circumstances, polity, society, economy that influences any kind of writing and its subsequent production

Learning Resources	
Text Book	1. Swan, Michael. Practical English Usage. New Delhi: Oxford University Press,2005. 2. Murphy,Herta A. Effective Business Communication,NewDelhi:McGrawHill,2008. 3. Nikolai Gogol, "The Overcoat". 4. P.B. Shelley, "To The Skylark" 5. Edgar Allan Poe, "The Raven" 6. H.H. Munro, "The Open Window"
Reference Book and other materials	1. Koneru, Aruna. Professional Speaking Skills. New Delhi: Oxford University Press, 2015. 2. Sanjay Kumar and PushpLata. Technical Communication, New Delhi: Oxford University Press,2008. 3. Koneru, Anuna. Professional Communication, New Delhi: McGraw Hill Pvt. Ltd, 2008. 4. Rizvi,M.Ashraf.EffectiveTechnicalCommunication,NewDelhi:McGrawHill,2018. 5. Barun K. Mitra, Personality Development and Soft Skills, Oxford University Press, New Delhi,2011.

Generic Elective – II

Course Code	Subject Name	L	T	P	C
19GEPH102	Physics II- Elements of Modern Physics	3	0	0	3
GE	Pre-requisite				
	Co-requisite				
	Designed by Physics Department				

COURSE OBJECTIVE:

1. To gain insight into the evolution of Physics.
2. To learn basics of Quantum Physics
3. To know about the elements of Nuclear Physics

UNIT	Course contents	Contact Hours
Unit-I	**MATTER WAVES & LIGHT:** Planck's quantum theory, Light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson Germer experiment. Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.	8
Unit-II	**UNCERTAINITY RELATION:** Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.	7
Unit-III	**WAVE MECHANICS & OPERATORS**: Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wave function, probabilities and normalization; Probability and probability current densities in one dimension.	7
Unit-IV	**APPLICATION OF SCHRODINGER EQUATION:** One dimensional infinitely rigid box- energy eigenvalues and Eigen functions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension - across a step potential	7
Unit-V	**NUCLEAR PHYSICS:** Radioactivity: stability of nucleus; Law of radioactive decay; Mean life & half-life; α decay; β decay - energy released, γ-ray emission. Fission and Fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons; Fusion and thermonuclear reactions.	8

LEARNING OUTCOME: The student is expected to be familiar with

1. Evolution and concepts of Modern Physics
2. Introductory knowledge of quantum mechanics and nuclear physics
3. Application of Schrodinger Equation

Learning Resources	
Text Book	1. Beiser Arthur, Concepts of Modern Physics, Tata McGraw-Hill Edition Reprint 2010. 2. Mahesh C Jain, Quantum Mechanics, PHI LearningPvt. Ltd, 2nd Edition, 2017.
Reference Book and other materials	1. Tayal D.C., Nuclear Physics, Himalaya Publishing House, 2009. 2. SrivastavaJ.P , Elements of Solid State Physics, Prentice Hall of India Pvt. Ltd., 2nd Edition 2006. 3. Murugeshan R. and Kiruthiga S., Modern Physics, S. Chand & Co, 18th Edition 2016.

Course Code	Subject Name	L	T	P	C
19GEPH 104	Physics Laboratory-II	0	0	2	1
GE	Pre-requisite				
	Co-requisite				
	Designed by Physics Department				

Experiment	Name of Experiment
Experiment 1	To calculate the Young's modulus of a given material using the method of uniform/non-uniform bending of beam.
Experiment 2	To study the photoconductive nature of the given light dependent resistor (LDR).
Experiment 3	To determine the energy band gap of a semiconductor (Germanium) using four probe method.
Experiment 4	To calibrate the electromagnet using the Hall-Probe Gauss meter.
Experiment 5	To determine the dielectric constant of the given sample at different temperatures.
Experiment 6	To measure the susceptibility of paramagnetic solution by Quincke's tube method.
Experiment 7	To determine the size of micro particles using laser.
Experiment 8	To determine the V-I characteristics of a solar cell.

Learning Resources	
Text Book	1. Chattopadhyay, D., Rakshit, P. C and Saha, B., "An advanced Course in Practical Physics", 2nd edition, Books & Allied Ltd, Calcutta, 1990.
Reference Book and other materials	1. Chauhan and Singh, "Advanced practical physics", Revised edition, PragatiPrakashan Meerut, 1985. 2. Thiruvadigal. J. D., Ponnusamy S. Vasuhi, P. S. and Kumar. C, "Hand Book of Practical physics", 5th edition, Vibrant Publication, Chennai, 2007.

Course Code	Subject Name	L	T	P	C
CYG-102	Inorganic and General Organic Chemistry	3	0	0	3
GE	Pre-requisite				
	Co-requisite				
	Designed by Chemistry Department				

COURSE OBJECTIVE:

1. This course provides fundamental knowledge of Inorganic and General Organic Chemistry.
2. Further, this course focuses on Atomic Structure & Chemical Bonding, Organic chemistry with special reference to its Stereochemistry.

UNIT	Course contents	Contact Hours
Unit-I	Atomic Structure:Bohr's theory and its limitations, heisenberg uncertainty principle, dual behavior of matter and radiation, de-Broglie's relation, hydrogen atom spectra,quantummechanics,Schrodinger equation and meaning,significance of ψ and ψ2, Schrödinger equation for hydrogen atom, radial and angular parts (atomic orbitals) and their graphical representation, nodes and their significance, nodal planes, radial distribution functions, quantum numbers and their significance, shapes of various orbitals (s, p, d and f atomic orbitals),rules for filling electrons in various orbitals.	8
Unit-II	Chemical Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, statement of born-landé equation for calculation of lattice energy, born-haber cycle and its applications, polarizing power and polarizability,fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: valence band theory.	8
Unit-III	General Organic Chemistry: Electronic displacements: inductive, electrometric, resonance and mesmeric effects, hyper conjugation and their applications; dipole moment; organic acids and bases; their relative strength.Hemolytic and heterolysis fission with suitable examples.curlyarrow rules, formal charges; electrophiles and nucleophiles; nucleophlicity and basicity; types, shape and their relative stability of carbocations, carbanions, free radicals and carbenes, benzyne, aromaticity: benzenoids and hückel's rule.	8
Unit-IV	Stereochemistry: Nomenclature systems D & L, R & S and E & Z, CIP rules. fischer projection, newmann and sawhorse projection formulae and their interconversions; conformational analysis of ethane, butane, cyclohexane. Interconversion of wedge formula, newmann, sawhorse and fischerrepresentations,elements of symmetry, chirality, molecules with more than one chiral center, enantiomerism, diastereomerism and meso compounds threo and erythro isomers.	8

LEARNING OUTCOME:

1. Students should have a working knowledge of the main areas of chemistry: Organic and Physical Chemistry.
2. Students should be able to work in a chemical or a related field.
3. Students will be able to clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.
4. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists, including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
5. Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
6. Students will be able to function as a member of an interdisciplinary problem solving team.

Learning Resources	
Text Book	1. Lee, J.D. Concise Inorganic Chemistry, 5th Edition, 2008. 2. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry, 3rd Edition 1994, Wiley. 3. Douglas, B.E., McDaniel, D.H. & Alexander, J. J., Concepts and Models of Inorganic Chemistry, John Wiley & Sons, 1994. 4. Bahl, A. &Bahl, B.S., Advanced Organic Chemistry, S. Chand Publishing, 2012.
Reference Book and other materials	1. Huheey, J.E., Keiter, E.A., Keiter, R.L. &Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 1997. 2. Sykes, P., A Guidebook to Mechanism in Organic Chemistry, Pearson India, 2013. 3. Finar, I.L., Organic Chemistry (Vol. I & II), Pearson Education India, 1973. 4. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2017. 5. Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2001.

Course Code	Subject Name	L	T	P	C
CYG-102L	Inorganic Chemistry & Organic Chemistry Practical	0	0	2	1
GE	Pre-requisite				
	Co-requisite				
	Designed by Chemistry Department				

Experiment	Name of Experiment
Practical Inorganic Chemistry	
Experiment 1	Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
Experiment 2	Estimation of oxalic acid by titrating it with KMnO4.
Experiment 3	Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator.
Practical Organic Chemistry	
Experiment 4	Determination of Melting point and Boiling point of an organic compound
Experiment 5	Detection of extra elements (N, S, Cl, Br, I) in organic compounds
Experiment 6	Separation of mixtures by Chromatography: Measure the Rf value in each case (a) Identify and separate the components of a given mixture on the basis of polarity by paper chromatography (b) Role of eluting solvent (mobile phase) on Rf.

Learning Resources	
Text Book	1. Mann, F.G. & Saunders, B.C., Practical Organic Chemistry, Pearson Education India; 4th edition, 2009. 2. Svehla, G., Vogel's Qualitative Inorganic Analysis, Pearson Education 7th Edition, 1996.
Reference Book and other materials	1. Mendham, J., Vogel's Quantitative Chemical Analysis, Pearson Education; 6th Edition, 2009. 2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Pearson; 5th Edition,1996. 3. Gulati A., Dhingra, S., Ahluwalia V K, College Practical Chemistry, Universities Press, 2005. 4. Pandey, O.P.; Bajpai, D. N.; Giri, S., Practical Chemistry, S. Chand Limited, 1972.

Course Code	Subject Name	L	T	P	C
20BMH0203	Programming in MATLAB	3	0	2	4
GE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. The course provides a gentle introduction to the MATLAB computing environment, and is intended for beginning users and those looking for a review.
2. It is designed to give students a basic understanding of MATLAB, including popular toolboxes.

UNIT	Course contents	Contact Hours
Unit-I	Practicing MATLAB environment with simple exercises to familiarize Command Window, History, Workspace, Current Directory, Figure window, Edit window, Shortcuts, Help files.	8
Unit-II	Data types, Constants and Variables, Character constants, operators, Assignment statements. Control Structures: For loops, While, If control structures, Switch, Break, Continue statements.	8
Unit-III	Input-output functions, Reading and Storing Data, Vectors and Matrices, commands to operate on vectors and matrices, matrix Manipulations.	8
Unit-IV	Arithmetic operations on Matrices, Relational operations on Matrices, Logical operations on Matrices.	8
Unit-V	Polynomial Evaluation, Roots of Polynomial, Arithmetic operations on Polynomials, Graphics, 2D plots, Printing labels, Grid & Axes box, Text in plot, Bar and Pie chart. Linear Equations.	8

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Find importance of this software for Lab Experimentation.
2. Write basic mathematical problems in Matlab.
3. Design and conduct experiments, as well as to analyze and interpret data.

Learning Resources	
Text Book	1. Stephen J.Chapman, "Programming in MATLAB for Engineers", Cengage Learning, 2011. 2. Pratap R., Getting started with MATLAB: A Quick introduction for Scientists & Engineers, Oxford University Press, 2010.
Reference Book and other materials	1. Bansal R.K, Goel A.K., Sharma M.K., "MATLAB and its Applications in Engineering", Pearson Education, 2012. 2. Amos Gilat, "MATLAB-An Introduction with Applications", Wiley India, 2009.

Course Code	Subject Name	L	T	P	C
19BMH0203L	Programming in MATLAB	0	0	2	1
GE	Pre-requisite				
	Co-requisite				
	Designed byMathematics Department				

COURSE OBJECTIVE:

1. To learn and Practice the basics of MATAB

INSTRUCTIONAL OBJECTIVES

To learn & practice the MATLAB.

LEARNING OUTCOME:

On completion of this course, the students will be able to

1. Become familiar with fundamental operations in MATLAB.
2. Perform statistical data analysis, data interpolation by MATLAB, solve differentiation equation with MATLAB.
3. Acquire a reasonable level of competence in designing optimization algorithms, solve linear programming, constrained and unconstrained optimization problems by MATLAB.

Learning Resources	
Text Book	Laboratory Manual
Reference Book and other materials	Laboratory Manual

Skill Enhancement Course – II

Course Code	Subject Name	L	T	P	C
19BMH0204	Data Structures	3	0	0	3
SEC	Pre-requisite				
	Co-requisite				
	Designed by Computer Science and Technology				

COURSE OBJECTIVE:

1. This course describes lists, stacks, queues, binary search trees, AVL trees, heaps, hash tables.
2. Applications: searching, sorting, evaluation of infix/postfix expressions, priority scheduling.

UNIT	Course contents	Contact Hours
Unit-I	Data structure and its essence, Data structure types, Linear and list structures: Arrays, stacks, queues and lists; Sequential and linked structures; Simple lists, circular lists, doubly linked lists, Inverted lists, threaded lists, Operations on all these structures and applications.	8
Unit-II	Arrays, Multidimensional arrays, sequential allocation, address calculations, sparse arrays.	8
Unit-III	Tree structures: Trees, binary trees and binary search trees, implementing binary trees, Tree traversal algorithms, threaded trees, trees in search algorithms, AVL Trees.	8
Unit-IV	Graph data structure and their applications, Graph traversals, shortest paths, spanning trees and related algorithms. Family of B-Trees: B-tree, B*-Trees, B+ Trees.	8
Unit-V	Sorting: Internal and external sorting, various sorting algorithms, Time and Space complexity of algorithms,Searching techniques and Merging algorithms, Applications of sorting and searching in computer science.	8

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Develop knowledge of basic data structures for storage and retrieval of ordered or unordered data.
2. Develop knowledge of applications of data structures.
3. Implement algorithms for the creation, insertion, deletion, searching, and sorting
4. Analyze and compare algorithms for efficiency using Big-O notation.

Learning Resources	
Text Book	1. Lipschutz: Data Structures (Schaum's Outline Series), Tata McGraw-Hill First Edition 2014. 2. Adam Drozdek: Data Structures and Algorithms in C++, Cengage, 4th edition 2013.
Reference Book and other materials	1. Gupta Amit: Data Structures Through C, GalgotiaBooksource Pvt. Ltd., New Delhi, 2015. 2. Dromey R.G: How to solve it by Computer? Pearson India 2007. 3. Tannenbaum: Data Structure Using C, Pearson Education First Edition 2019.

Course Code	Subject Name	L	T	P	C
20BMH0205	Logic and Sets	3	0	0	3
SEC	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course aims to give the knowledge about propositions, truth table and logical operators, predicates, quantifiers, sets and its types, relations and its representations.

UNIT	Course contents	Contact Hours
Unit-I	Introduction, propositions, truth table, negation, conjunction and disjunction, Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Tautology and contradiction, Duality law, Normal forms	8
Unit-II	Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.	7
Unit-III	Sets, subsets, Set operations and the laws of set theory and Venn diagrams, Finite sets and counting principle, Empty set, properties of empty set, Standard set operations, Classes of sets,Power set of a set. Partition of set.	8
Unit-IV	Difference and Symmetric difference of two sets, Set identities, generalized union and intersections.	7
Unit-V	Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, and nary relations.	8

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Define propositions and can establish valid logics.
- Understand of theory of sets and its algebraic properties.
- Analyze equivalent relations and partial ordering relations.

Learning Resources	
Text Book	1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 2006. 2. Samar BallavBhoi, A Text Book of Logic and Sets, Educreation Publishing, 2018.
Reference Book and other materials	1. Tremblay J. P. and Manohar R., Discrete Mathematical Structures with applications to Computer Science, Tata McGraw Hill Publishing Co., 35th edition,2008. 2. Rosen, Kenneth H., Discrete Mathematics and its applications, McGraw Hill, 6th Edition, 2007.

Ability Enhancement Compulsory Course – II

Course Code	Subject Name	L	T	P	C
20AEC0102	Environmental Studies	3	0	0	3
AECC	Pre-requisite				
	Co-requisite				
	Designed by Department of Environmental Studies				

COURSE OBJECTIVE: The courses to enhance knowledge skills and attitude towards environment. Also to understand natural environment and its relationship with human activities.

UNIT	Course contents	Contact Hours
Unit-I	**INTRODUCTION** • Introduction to environmental studies • Multidisciplinary nature of environmental studies • Scope and importance • Need for public awareness.	8
Unit-II	**ECOSYSTEMS** • Concept of an ecosystem. • Structure and function of an ecosystem. • Energy flow in an ecosystem: food chains, food webs and ecological pyramids. • Ecological succession. • Case studies of the following ecosystems: a) Forest ecosystem b) Grassland ecosystem c) Desert ecosystem d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)	8
Unit-III	**NATURAL RESOURCES: RENEWABLE & NON-RENEWABLE RESOURCE**S • Land resources and land use change: Land as a resource, land degradation, landslides (natural &man-induced), soil erosion and desertification. • Forests & forest resources: Use and over-exploitation, deforestation, case studies. • Impacts of deforestation, mining, dam building on environment, forests, biodiversity and tribal Populations. • Resettlement and rehabilitation of project affected persons; problems and concerns, case studies • Water resources: Use and over-exploitation of surface and ground water, floods, drought, conflicts over water (international & inter-state). • Food resources: World food problems, changes caused by agriculture	8

	and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. • Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs, case studies.	
Unit-IV	**BIODIVERSITY & CONSERVATION** • Levels of biological diversity: genetic, species and ecosystem diversity. • Biogeographic zones of India • Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational values • Biodiversity patterns and global biodiversity hotspots • India as a mega-biodiversity nation; Endangered and endemic species of India • Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions. • Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.	8
Unit-V	**ENVIRONMENTAL POLLUTION** • Definition • Types of pollutants • Causes, effects and control measures of (a) Air pollution (b) Water pollution • Solid waste management	8

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Enhance and analyze human impacts on the environment.
2. Integrate concept and methods from multiple disciplines and apply to environmental problems.
3. Design and evaluate strategic technologies and methods for sustainable management of environmental systems.

Learning Resources	
Text Book	1. Kurian Joseph & R. Nagendran, "Essential of Environmental Studies" "Pearson Education, 2004.
Reference Book and other materials	1. Dara S.S., A Text Book of Environmental Chemistry and pollution control, S.Chand& Company Ltd., New Delhi, 2004. 2. Jeyalakshmi.R, Principles of Environmental Science, 1st Edition, Devi Publications, Chennai 2006. 3. Kamaraj.P&Arthanareeswari.M, Environmental Science – Challenges and Changes, 1st Edition, Sudhandhira Publications, 2007. 4. Arivalagan.K, Ramar.P&Kamatchi.P, Principles of Environmental Science, 1st Edition, Suji Publications, 2007. 5. K, Ramar.P&Kamatchi.P, Principles of Environmental Science, 1st Edition, Suji Publications, 2007.

Discipline Specific Elective-I

Course Code	Subject Name	L	T	P	C
19BMH0305	Applications of Algebra	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: This course aims to give knowledge Balanced incomplete block designs (BIBD), Coding Theory, Symmetry groups and color patterns and Application of linear transformations.

UNIT	Course contents	Contact Hours
Unit-I	Balanced incomplete block designs (BIBD): definitions and results, incidence matrix of a BIBD, construction of BIBD from difference sets, construction of BIBD using quadratic residues, difference set families, construction of BIBD from finite fields.	10
Unit-II	Coding Theory: introduction to error correcting codes, linear cods, generator and parity check matrices, minimum distance, Hamming Codes, decoding and cyclic codes.	10
Unit-III	Symmetry groups and color patterns: review of permutation groups, groups of symmetry and action of a group on a set; colouring and colouring patterns, Polya theorem and pattern inventory, generating functions for non-isomorphic graphs.	10
Unit-IV	Application of linear transformations: Fibonacci numbers, incidence models, and differential equations. Lease squares methods: Approximate solutions of system of linear equations, approximate inverse of an mxn matrix, solving a matrix equation using its normal equation, finding functions that approximate data.	10
Unit-V	Linear algorithms: LDU factorization, the row reduction algorithm and its inverse, backward and forward substitution, approximate substitution, approximate inverse and projection algorithms.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Know linear cods, Hamming Codes, decoding and cyclic codes.
2. Recognize coloring and coloring patterns.
3. Recognize Fibonacci numbers, incidence models, and differential equations.
4. Know Lease squares methods, approximate solutions of system of linear equations.
5. Do LDU factorization and apply the row reduction algorithm.
6. Apply projection algorithms.

Learning Resources	
Text Book	1. S.R. Nagpaul and S.K. Jain, Topics in Applied Abstract Algebra, American Mathematical Society, 2010. 2. D. S. Dummit and R. M. Foote, Abstract Algebra, John-Wiley, 2nd Edition, 1999.
Reference Book and other materials	1. J. B. Fraleigh, a First Course in Abstract Algebra, Pearson, 7 thEdition, 2003. 2. I.N. Herstein and D.J. Winter, Primer on Linear Algebra, Macmillan Publishing Company, New York, 1990.

Course Code	Subject Name	L	T	P	C
19BMH0306	Integral Transforms	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: The course aims to equip the students with the knowledge of slightly advanced topics of mathematics.

UNIT	Course contents	Contact Hours
Unit-I	Laplace Transforms – Existence theorem for Laplace transforms, Linearity of the Laplace transforms, shifting theorems, Laplace transforms of derivatives and integrals, Differentiation and integration of Laplace transforms.	10
Unit-II	Convolution theorem, Inverse Laplace transforms, convolution theorem, Inverse Laplace transforms of derivatives and integrals, solution of ordinary differential equations using Laplace transform.	10
Unit-III	Introduction, Dirichlet's conditions and general Fourier series, Odd and even functions, half range Expansions and Parseval's identity.	10
Unit-IV	Fourier transforms: Linearity property, Shifting, Modulation, Convolution Theorem, and Fourier Transform of Derivatives. Fourier Integral Theorem.	10
Unit-V	Relations between Fourier transform and Laplace transform, Parseval's identity for Fourier transforms, solution of differential Equations using Fourier Transforms.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Know the rudiments of Fourier series.
2. Apply Laplace Transforms and Fourier Transform.
3. Solve differential equations by Laplace transform.
4. Understand Dirichlet's conditions, Parseval's identity.
5. Solve differential Equations using Fourier Transforms.

Learning Resources	
Text Book	1. Erwin Kreyszing: Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 10th Edition 2015
Reference Book and other materials	1. A.R. Forsyth: A Treatise on Differential Equations, CBS, 1st Edition, 2005. 2. I.N. Sneddon: Special Functions on mathematics, Physics & Chemistry Oliver & Boyd; New Impression edition 1966. 3. W.W. Bell: Special Functions for Scientists & Engineers Dover Publications 2013. 4. Murray R. Spiegel: Laplace transform, Schaum's Series, McGraw Hill Education, 2005.

Course Code	Subject Name	L	T	P	C
19BMH0307	Econometrics	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. Econometrics is a set of research tools used to estimate and test economic relationships.
2. The methods taught in this introductory course can also be employed in the business disciplines of accounting, finance, marketing and management and in many social science disciplines.
3. The emphasis of this course will be on understanding the tools of econometrics and applying them in practice.

UNIT	Course contents	Contact Hours
Unit-I	Normal distribution, chi-sq, t- and F-distributions, estimation of parameters, properties of estimators, testing of hypotheses, defining statistical hypotheses, distributions of test statistics.	11
Unit-II	Testing hypotheses related to population parameters, Type I and Type II errors, power of a test, tests for comparing parameters from two samples.	9
Unit-III	Multiple Linear Regression Model Estimation of parameters, properties of OLS estimators, goodness of fit - R2 and adjusted R2, partial regression coefficients, testing hypotheses – individual and joint, functional forms of regression models, qualitative (dummy) independent variables.	10
Unit-IV	Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity, heteroscedasticity, serial correlation.	10
Unit-V	Specification Analysis Omission of a relevant variable, inclusion of irrelevant variable, tests of specification errors.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Know normal distribution and estimation of parameters.
2. Understand the concept of testing of hypothesis.
3. Know about OLS estimators and partial regression.
4. The concept of multicollinearity and heteroscedasticity.
5. Understand Specification Analysis.

Learning Resources	
Text Book	1. D. N. Gujarati and D.C. Porter, Essentials of Econometrics, McGraw Hill, 4th Ed., International Edition, 2009.
Reference Book and other materials	2. Richard J. Larsen and Morris L. Marx, an Introduction to Mathematical Statistics and its Applications, Prentice Hall, 2011. 3. Christopher Dougherty, Introduction to Econometrics, Oxford University Press, 3rd Ed., Indian edition, 2007. 4. Jay L. Devore, Probability and Statistics for Engineers, Cengage Learning, 2010.

Discipline Specific Elective-II

Course Code	Subject Name	L	T	P	C
19BMH0405	Operations Research II	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course gives knowledge about the operations research problem in the context of real life situations.
2. The course includes game theory and applications, sequencing problems, network analysis, and inventory and queuing models with applications.

UNIT	Course contents	Contact Hours
Unit-I	Game Theory: Optimal solution of two person zero sum games mixed strategies, graphical solution of (2xn) and (mx2) games - solution of (mxn) games by linear programming.	10
Unit-II	Problem of sequencing – Processing 'n' jobs through two machines, three machines, processing two jobs through 'm' machines, Replacement model – Replacement of items that deteriorate, gradually, fail suddenly, group replacement policy analysis.	10
Unit-III	Network analysis – PERT and CPM, Total slack, free slack, Probability of achieving completion date, Cost analysis.	10
Unit-IV	Inventory models – Deterministic models – Economic ordering quantity, Reorder level, optimum cost – Instantaneous and Non-instantaneous receipt of goods with or without shortages.	10
Unit-V	Introduction to Markovianqueueing models – Single server model with finite and infinite system capacity – Characteristics of the model; Applications of queueing theory.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Define and formulate the problems of game theory.
2. Solve the problems based on sequencing and network analysis.
3. Conduct and interpret inventory models.
4. Develop mathematical skills to analyze and solve queuing models.

Learning Resources	
Text Book	1. Handy A. Taha, "Operations Research", Prentice Hall of India., 5th Edition, 2012 2. KantiSwarup, Gupta P.K., and Man Mohan, Operations Research, Sultan Chand & Sons, 1994.
Reference Book and other materials	1. Sharma S.D., Operations Research, Kedarnath Ramnath& Co., Meerut, 2013. 2. Sharma J. K., Operations Research: Theory and Applications, Macmillan Publishers India Limited, 2011. 3. Sundaresan.V, Ganapathy Subramanian.K.S. and Ganesan.K, Resource Management Techniques, A.R. Publications, 2002.

Course Code	Subject Name	L	T	P	C
19BMH0406	Mathematical Modeling	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course aims to give knowledge about mathematical modeling.
2. The course includes Empirical Modeling, Multiple Regression and Spline models, Simulation modeling and queuing model.

UNIT	Course contents	Contact Hours
Unit-I	Introduction, Definition, purpose, process and assumptions, modelling with proportionality, fitting straight lines analytically, Geometric similarity.	12
Unit-II	Empirical Modelling, Linearizable models, coefficient of determination, polynomials, Multiple Regression and Spline models.	10
Unit-III	Discrete Dynamical systems: long term behavior and equilibrium, growth of bacteria population. Linear and Nonlinear predator- prey models, Epidemics.	9
Unit-IV	Simulation modeling: Introduction, The birthday problem, random number generators, Modeling random variables and approximating density functions.	10
Unit-V	A theoretical queuing model, a coffee shop queuing model, scheduling model and Inventory model.	9

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Work with excel environment.
2. Understand mathematical modeling with proportionality
3. Apply empirical model and Spline models to the problems
4. Apply Linear and Nonlinear predator for Epidemics.
5. Generate random numbers and solve the problem with the help of simulation modeling

Learning Resources	
Text Book	1. Brian Albright, Mathematical modeling with Excel,Jones& Bartlett India Private Limited, 2010.
Reference Book and other materials	1. Danielle Stein Fairhurst, Financial Modeling in Excel for Dummies, John Wiley & Sons, 2017. 2. Functions, Data, and Models, Gordon and Gordon, the Mathematical Association of America, 2010. 3. Jim Caldwell, Douglas K.S. Ng, Mathematical Modelling: Case Studies and Projects, Kluwer Texts in the Mathematical Sciences, volume 28, Kluwer Academic Publishers, 2004.

Course Code	Subject Name	L	T	P	C
19BMH0407	Industrial Mathematics	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: This course aims to introduce Inverse problems through mathematical approach and gain basic knowledge of Mathematics of X-ray, CT scan and radon transform.

UNIT	Course contents	Contact Hours
Unit-I	Medical Imaging and Inverse Problems, The content are based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.	10
Unit-II	Introduction to Inverse problems: Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations.	9
Unit-III	A geological anomaly in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.	10
Unit-IV	X-ray: Introduction, X-ray behavior and Beers Law (The fundamental question of image construction) Lines in the place.	10
Unit-V	Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms). Back Projection: Definition, properties and examples. CT Scan: Properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.	11

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Understand medical imaging and inverse problems.
2. Know about Geological anomalies in Earth's interior.
3. Know Algebraic reconstruction techniques abbreviated.
4. Understand X-ray behavior and Beers Law.

Learning Resources	
Text Book	1. T.K.Manickavachagam Pillai, Matrices, S.Viswanathan Printers & Publishers, 2012.
Reference Book and other materials	1. Timothy G. Feeman, The Mathematics of Medical Imaging, A Beginners Guide (Springer Under graduate Text in Mathematics and Technology), Springer, 2015. 2. C.W. Groetsch, Inverse Problems, Activities for Undergraduates, The Mathematical Association of America, 1999. 3. Andreas Kirsch, an Introduction to the Mathematical Theory of Inverse Problems, 2nd Ed, Springer, 2011.

Discipline Specific Elective-III

Course Code	Subject Name	L	T	P	C
20BMH0504	Non Liner Programming and Simulation Theory	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course aims to make familiar to the students with the concept of nonlinear programming and simulation theory.
2. The course extends up to unconstrained optimization, constrained multivariable optimization, Monte Carlo simulations and its applications.

UNIT	Course contents	Contact Hours
Unit-I	Unconstrained optimization, optimizing single variable functions, conditions for local minimum and maximum value, optimizing multivariable functions, constrained multivariable optimization with equality constraints, direct substitution method and Lagrange multiplier methods.	11
Unit-II	Constrained multivariable optimization with inequality constraints, Kuhn Tucker necessary and sufficient conditions.	9
Unit-III	Introduction to general Nonlinear programming problems, Quadratic programming, Kuhn- Tucker conditions and Beale's Methods, Wolfe's modified simplex method, Applications of quadratic Programming.	10
Unit-IV	Simulation: introduction, types of simulation, Monte Carlo simulations and random number generation. Applications of Simulation: Simulation of Queuing problems and Simulation of PERT problems.Numerical Optimization Technique.	10
Unit-V	Search Optimization Techniques Numerical Optimization Technique, Exhaustive Search Methods.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Define Constrained and Unconstrained optimization.
2. Know Kuhn Tucker necessary and sufficient conditions.
3. Solve Quadratic programming using Beale'sand Wolfe's method.
4. Understand simulations, its types and applications.

Learning Resources	
Text Book	1. Handy A. Taha, "Operations Research", Prentice Hall of India., 5th Edition, 2012 2. KantiSwarup, Gupta P.K., and Man Mohan, Operations Research, Sultan Chand & Sons,1994.
Reference Book and other materials	1. P. K. Gupta, D. S. Hira, Operations Research, Sultan Chand Publication, Delhi, 2012. 2. Sharma S.D., Operations Research, KedarnathRamnath& Co., Meerut, 2013. 3. Sharma J. K., Operations Research: Theory and Applications, Macmillan Publishers India Limited, 2011.

Course Code	Subject Name	L	T	P	C
19BMH0505	Topology	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVEL:

1. This course aims to make familiar to the students with the concept of nonlinear programming and simulation theory.
2. The course extends up to unconstrained optimization, constrained multivariable optimization, Monte Carlo simulations and its applications.

UNIT	Course contents	Contact Hours
Unit-I	Definition and examples of topological space, Closed sets, Closure, Dense subset, Neighborhoods, interior, exterior, boundary and accumulation points, Derived sets, Bases and sub-bases. Subspaces, product spaces and relative topology.	12
Unit-II	Continuous functions, open maps, closed maps and homeomorphisms, Product topology, quotient topology, metric topology, Baire category theorem.	8
Unit-III	Countable and Uncountable Sets, Schroeder-Bernstein Theorem, Cantor's Theorem, Cardinal numbers and cardinal arithmetic.	10
Unit-IV	Continuum Hypothesis, Zorns Lemma, Axiom of Choice, Wellorderedsets,Hausdorff's maximal principle, Ordinal numbers.	10
Unit-V	Connected and path connected spaces, connected sets in R, components and path components, local connectedness, Compact spaces, compact sets in R, Compactness in metric spaces.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

1. Define Constrained and Unconstrained optimization.
2. Know Kuhn Tucker necessary and sufficient conditions.
3. Solve Quadratic programming using Beale'sand Wolfe's method.
4. Understand simulations, its types and applications.

Learning Resources	
Text Book	1. J. R. Munkres, Topology, Pearson Education India, 2015. 2. G. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Education, 2017.
Reference Book and other materials	1. J. L. Kelley, General Topology, Springer, 2018. 2. J. G. Hocking, G. S. Young, Topology, Dover Publications, 2012. 3. L. A. Steen, J. A. Seebach, Jr, Counter Examples in Topology, Springer, 1978.

Course Code	Subject Name	L	T	P	C
19BMH0506	**Bio-Mathematics**	**4**	**1**	**0**	**5**
DSE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course aims to gain basic knowledge of mathematical biology, and modeling process.
2. This module also introduces Holling type growth, Bacterial growth in a Chemostat, Spatial Models, and Discrete Models.

UNIT	Course contents	Contact Hours
Unit-I	Mathematical Biology and the modeling process: an overview,Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and LotkaVolterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect.	12
Unit-II	Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation, Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.	10
Unit-III	Spatial Models: One species model with diffusion, two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in the circulatory system, travelling wave solutions, spread of genes in a population.	8
Unit-IV	Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, and Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models.	10
Unit-V	Numerical solution of the models and its graphical representations, Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Understand Mathematical modeling in biology.
2. Illustrate and apply continuous and discrete models.
3. Analyze case studies based on Optimal Exploitation models, Models in Genetics, Stage Structure Models, and Age Structure Models.
4. Find the numerical solution of the models and its graphical representations.

Learning Resources	
Text Book	1. L.E. Keshet, Mathematical Models in Biology, SIAM, 2005.
Reference Book and other materials	1. J. D. Murray, Mathematical Biology: I. An Introduction (Interdisciplinary Applied Mathematics), Springer, 2008. 2. Y.C. Fung, Biomechanics: Motion, Flow, Stress, and Growth, Springer-Verlag, 1990. 3. F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2013. 4. M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

Discipline Specific Elective-IV

Course Code	Subject Name	L	T	P	C
19BMH0604	Discrete Mathematics	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. The course aims to give understanding of Logic and mathematical reasoning and to enumerate objects in a systematic way.
2. Further, the module gives knowledge of Boolean Algebra, Graphs and its types, Recurrence Relation, Generating functions.

UNIT	Course contents	Contact Hours
Unit-I	Propositions and Logical operators - Truth tables and propositions generated by a set - Equivalence and Implication - Tautologies - Laws of logic - Proofs in Propositional calculus -Direct proofs - Conditional conclusions - Indirect proofs - Propositions over a universe -Mathematical Induction - The existential and universal quantifiers.	10
Unit-II	Laws of Set theory - Partition of a set - Minsets - The duality principle - Relations – Graphsof relations - Hasse diagram - Matrices of relations - Closure operations on relations -Warshall'salgorithm .	10
Unit-III	Recurrence relations - Solving a recurrence relation - Recurrence relations obtained fromsolutions - Generating functions - Solution of a recurrence relation using generating functions- Closed form expression for generating function.	10
Unit-IV	Graphs: Definition and terminology, Representation of graphs, Multigraphs, Bipartite graphs, Planar graphs, Isomorphism and Homeomorphism of graphs, Euler and Hamiltonian paths, Graph coloring.Basic concepts - Data structures for graphs - Connectivity - Traversals graph optimization -The traveling salesman problem and networks and the maximum flow problem - Trees -Spanning Trees - Rooted trees - Binary Trees - Kruskal's algorithm - Traversals of Binarytrees.	10
Unit-V	Boolean algebra –Duality, Boolean Functions, Simplification of Boolean Functions, Canonical Form. Posets–Partially Ordered Set, Hasse Diagram, Elements in Posets, Linearly ordered Set, Well ordered Set, Product order, Lexicographic Order, Topological Sorting and Consistent Enumeration, Isomorphism. Lattices –Properties of Lattices, Some Special Lattices, Product of lattices, Lattice Homomorphism.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Define ordered sets and modular, lattices.
2. Understand Boolean algebra and Boolean polynomials.
3. Apply shortest path, Dijkstra’s algorithm, Floyd-Warshall algorithm.

Learning Resources	
Text Book	1. B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 2009.
Reference Book and other materials	1. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, Pearson Education Indian, 2015. 2. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, Springer, 2010. 3. Tremblay J. P. and Manohar R., Discrete Mathematical Structures with applications to Computer Science, Tata Major Core Graw Hill Publishing Co., 35th edition,2008.

Course Code	Subject Name	L	T	P	C
20BMH0605	Fuzzy Set Theory	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE: The purpose of this course is to introduce the basic knowledge of fuzzy sets and Fuzzy logic, knowledge representation using fuzzy rules, Logical connectives and fuzzy graphs, fuzzy Inference systems, and exposed to basic fuzzy system modelling methods.

UNIT	Course contents	Contact Hours
Unit-I	Fuzzy Sets: Basic definitions, level sets, convex fuzzy sets, basic operations on fuzzy sets, Types of fuzzy sets, Cartesian products, and algebraic products bounded sum and difference.	10
Unit-II	Fuzzy Relations and Fuzzy Graphs: Fuzzy relations on fuzzy sets, composition of fuzzy relations, Fuzzy graphs. Fuzzy Analysis: Fuzzy functions and their extreme, integration of fuzzy functions, Fuzzy differentiation	10
Unit-III	Fuzzy linear programming problems: Symmetric fuzzy linear programming problem, fuzzy linear Programming with crisp objective function, fuzzy graph.	10
Unit-IV	Systems and Fuzzy Control: Expert systems, uncertainty modeling in expert systems, fuzzy control, Process of fuzzy control. Fuzzy decisions, fuzzy linear programming problems, fuzzy transportation Problems.	10
Unit-V	An overview of classic logic, its connectives, tautologies, contradiction fuzzy logic, fuzzy quantities, Logical connectives for fuzzy logic, applications to control theory.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Understand the basic knowledge of fuzzy sets and fuzzy logic.
2. Be familiar with the concept of fuzzy numbers and arithmetic operations.
3. Be thorough with the concept of Logical connectives and fuzzy graphs.
4. Know the concepts of fuzzy graph, fuzzy relation, fuzzy morphism and fuzzy numbers.
5. Be exposed to basic fuzzy system modelling methods and knowledge of fuzzy information processing

Learning Resources	
Text Book	1. S. Nanda and N. R. Das, Fuzzy Mathematical concepts, Narosa Publishing House, New Delhi, 2010.
Reference Book and other materials	1. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 4th Edition 2015. 2. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1999. 3. M.Ganesh, Introduction to Fuzzy Sets & Fuzzy Logic, Prentice Hall of India Pvt. Ltd., 2006. 4. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.

Course Code	Subject Name	L	T	P	C
19BMH0606	Differential Geometry	4	1	0	5
DSE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

1. This course aims to gain basic knowledge of Evaluates and involutes of curves.
2. This module also introduces Euler's theorem, Conjugate, Asymptotic lines, algebra of tensors and contraction.

UNIT	Course contents	Contact Hours
Unit-I	Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres, Existence of space curves, volutes and involutes of curves.	10
Unit-II	Theory of Surfaces: Parametric curves on surfaces, Direction coefficients, First and second Fundamental forms, Principal and Gaussian curvatures, Lines of curvature, Euler's theorem, Rodrigue's formula, Conjugate and Asymptotic lines.	10
Unit-III	Developable: Developable associated with space curves and curves on surfaces, Minimal surfaces.	10
Unit-IV	Geodesics: Canonical geodesic equations, Nature of geodesics on a surface of revolution,Clairaut's theorem. Normal property of geodesics, Torsion of a geodesic, Geodesic curvature, Gauss-Bonnet theorem, Surfaces of constant curvature, conformal mapping, Geodesic mapping. Tissot's theorem.	9
Unit-V	Tensors: Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.	11

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

1. Understand theory of space curves.
2. Understand of theory of Tensors and its various algebraic properties.
3. To understand Curl, Divergence and Laplacian operators in tensor form.

Learning Resources	
Text Book	1. T.J. Willmore, an Introduction to Differential Geometry, Dover Publications, 2012. 2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2014.
Reference Book and other materials	1. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press, 2016. 2. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1989. 3. S. Lang, Fundamentals of Differential Geometry, Springer-Verlag New York Inc, 2012.